THE EFFECT OF EXERCISE INTENSITY AND LEVEL OF PHYSICAL FITNESS ON STATE ANXIETY SCORES OF YOUNG ADULT MALES IMMEDIATELY FOLLOWING EXERCISE AND AFTER A DELAY

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The Effect of Exercise Intensity and Level of Physical Fitness on State Anxiety Scores of Young Adult Males Immediately Following Exercise and After a Delay

By

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A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Science

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January 1985

St. John's Newfoundland

ISBN 0-315-31048-0

Abstract

To assess the effects of exercise intensity and fitness level on state anxiety scores after exercise one hundred and fourteen male volunteers participated in a controlled experiment. All subjects exercised on a bicycle ergometer, the control group at an unstressed heart rate and the three experimental groups at 100, 120, and 140 bpm, respectively. Subjects were randomly assigned to groups. Measurements of state anxiety level were made prior ~~to,~~ immediately following and at twelve minutes after exercise. Subjects' levels of fitness and trait anxiety also were assessed. Analysis of covariance revealed a significant effect of exercise intensity at twelve minutes after exercise. Analysis using Dunnett's test showed that this difference resulted from a significant reduction in anxiety level for those who exercised at 140 bpm. Those who exercised at 100 and 120 bpm did not differ from the control group. The conclusion is that moderate exercise, assigned on an individual basis in terms of heart rate, is an effective means of alleviating anxiety.

Acknowledgements

I am grateful to Dr. M. J. Stones, my thesis supervisor, for his help and guidance throughout this project. I thank Drs. A. Kozma and C. Harley for their insight, comments and criticisms.

This thesis is dedicated to Joyce V. Johnson.

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The purpose of the following experiment is to assess the effects of an exercise session, of a predominantly aerobic nature, on levels of state anxiety after exercise.

It is clear from the literature that there are several variables which affect the relationship between exercise and anxiety levels. These will be discussed in detail below. Some are under the control of the experimenter, and can be manipulated. Others are subject defined, and consequently must be assessed. Manipulable variables include activity type, work intensity, exercise intensity and timing of assessment. Subject defined variables include initial level of anxiety and level of fitness (physiological response to work intensity).

Experimenter Defined Variables

Experimenter defined variables are those manipulated by the experimenter in the experiments to be described.

Participation in an exercise program involves, aside from aerobic expenditure, many other variables. These variables are not always measurable. For some individuals participation involves altering daily routine to include exercise. For others, the usual pattern of daily exercise is changed. Through program participation new acquaintances are made; the experimental situation is a novel social situation. The effect of these variables may be to augment or attenuate the psychological changes brought about by exercise itself. Indeed, such variables may be significant ones contributing to anxiety change. Generally, this problem has been dealt with in two ways, by comparing across different types of activities, and by comparing various intensities of activity.

Activity type

Comparisons across activities have been few. Studies have compared aerobic exercise with meditation (Bahrke and Morgan, 1978), rest (Bahrke and Morgan, 1978 and Morgan, Roberts and Feinerman, 1971), organized exercise and eating lunch (Wilson, Berger and Byrd, 1981) to determine relative effect on anxiety level. Such comparisons have yielded generally consistant results. The aerobic activity was neither better nor worse than the comparison activity in reducing anxiety. Bahrke and Morgan (1978) compared twenty minutes each of (1) exercise performed on a treadmill at 70% of self-imposed maximal heart rate, (2) meditation and (3) rest. The three groups were composed of 25 males. State anxiety, as measured by the STAI, decreased significantly for all three groups, and there were no between group differences. Morgan et. al. (1971) also found no differences between two exercise intensities and seventeen minutes of supine rest. In this case, none of the activities produced significant changes in anxiety scores. However, this study used a different measure of anxiety than the previous. Anxiety was assessed by the IPAT 8 Form Anxiety Battery, which is considered to be a measure of trait anxiety, (Morgan, 1982). Wilson, Berger and Byrd (1981) compared running, organized exercise and eating lunch. In their study, the running group was composed of 11 males and nine females who ran sub-eight minute miles; the exercise group, of two males and 11 females who participated in 40 minutes of organized exercise; and the final group, of six males and four females who usually ate lunch together. State anxiety was measured by the STAI before and immediately after the activity. While all three groups showed significant decrements in anxiety, the between group differences were not significant. These studies indicate that aerobic exercise is neither better nor worse than meditation, organized exercise, rest and eating lunch in facilitating a reduction in state anxiety.

However, concluding that the diversional nature of exercise is the only significant variable is unwarranted. Although the diversional components may be anxiety reducing, the possibility that the exertion component may have similar effects is neither precluded nor confirmed by the above findings. Clearly, laboratory studies are required that permit comparison between exertion and non-exertion conditions, with diversional variables controlled for. Studies that have employed such a design have compared expenditure levels by manipulating the intensity of the activity.

Intensity of activity

The intensity of an activity may be defined by reference either to the work load, or to the magnitude of the physiological response induced. These definitions will be referred to as work intensity and exercise intensity, respectively. Morgan, Roberts and Feinerman (1971), for example, controlled work intensity by varying the grade of a motor driven treadmill. Exercise intensity is indexed in terms of physiological responsivity, typically heart rate (Andres, Metz and Drash, 1978; Morgan and Horstman, 1976; and Sime, 1977). Equating subjects in terms of exercise intensity implies a physiological response of comparable magnitude, irrespective of subjects differences in prior fitness and work intensity. An expectation might be that moderate levels of exercise intensity are associated with greater reductions in anxiety after exercise. Both a physiological and a psychological rationale may be proposed to support this expectation. The physiological rationale is that cessation of moderate exercise is followed by reliable reductions in muscle tension, which is an important component of anxiety (deVries and Adams, 1972). The psychological rationale rests on the similarity between the somatic arousal states characteristic of exercise and anxiety, respectively (Ledwidge, 1980). Subjects may be more prone to attribute somatic arousal to exercise provided that exercise intensity is neither minimal nor severe. At severe intensities, the negative characteristics of high arousal may even be anxiety inducing.

When work intensity is the independent variable, all subjects perform at a preset work load. For fitter individuals the work is less strenuous than for the less fit. Morgan, Roberts and Feinerman (1971) found no significant effects of work intensity. In their study, 18 male and 18 female subjects walked at 3.5 mph on a motor driven treadmill for seventeen minutes. Work intensity was controlled by varying the grade of the treadmill; some subjects experienced a 0% grade, others a 5% grade and a control group participated in seventeen minutes of supine rest. Following exercise, anxiety scores as assessed by the IPAT were not significantly different between any of these groups.

There are two problems with the Morgan et. al. (1971) study. Firstly, the IPAT is designed for the assessment of trait anxiety scores and therefore, would not be expected to detect any change in state anxiety, (Morgan, 1982). Secondly, a problem inherent in any study which defines intensity by work load is that the magnitude of the physiological reaction varies with the fitness of the subject, thereby increasing the contribution from error in statistical evaluation. This premise is based on the assumption that any anxiety reducing effects of exercise will be mediated by the extent of the physiological change induced.

The requirements of research with exercise intensity are such that individuals perform to a preset cardiovascular level which is achieved by varying work load. The findings on the effects of exercise intensity on state anxiety levels following exercise are inconsistent. Morgan and Horstman (1976) found that anxiety, as measured by the STAI and the IPAT, decreased significantly 20-30 minutes after what they termed moderate or heavy exercise, but not after light exercise. However, the actual exercise intensities were not provided. Similarly, Sime (1977) reported no change in anxiety, as measured by the STAI, following light exercise. Andres, Metz and Drash (1978) also found that exercise intensity is a significant variable in effecting change in state anxiety. However, they found that higher exercise intensities were not effective in reducing anxiety, whereas the lower intensity produced a significant decrease in anxiety. In this study, 16 male subjects walked or ran on a motor driven treadmill for 20 minutes at 70, 80 and 90 percent of their age related maximum heart rate. Anxiety was measured by the State Anxiety Inventory (SAI). Significant decrements in state anxiety were evident following exercise for those who exercised at 70% of their age related maximum heart rate, but not for those at 80% and 90%. However, subjects exercising at the two higher intensities clearly were performing at close to their maximal abilities.

Cross study comparison is made difficult by the variation in methods. Firstly, the actual exercise intensities used in the Morgan and Horstman (1976) study are unknown. The two higher intensities in the Andres et. al. (1978) study are very high. Consequently, no firm conclusions may be derived with regard to the prior expectation that a moderate exercise intensity is most effective in reducing state anxiety. Secondly, Morgan et. al. (1976) employed the STAI; Andres et. al. (1978), the SAI. Finally, Andres et. al. (1978) assessed anxiety immediately after exercise; Morgan et. al. (1976) allowed a delay of 20-30 minutes. As will be discussed, this variable can have profound effects on reported level of anxiety.

Delay in measurement

In two studies where there were no immediately evident effects of exercise on level of state anxiety, effects were evident after a delay (Morgan and Horstman, (1976); and Mitchum, (1976)). Morgan and Horstman (1976) used a modified four-item STAI to assess the course of anxiety during exercise. They found that state anxiety increased during the first half of exercise, plateaued and remained elevated throughout. Anxiety began to decrease immediately following exercise, with significant decrements occurring at the tenth minute after exercise. In Mitchum's (1976) study, subjects participated in 15 minutes of racquetball. In this case, significant decrements in level of state anxiety occurred at 15 to 30 minutes after exercise.

Morgan and Bahrke (1972, unpublished findings cited in Morgan, 1973), Morgan (1973) and Seeman (1978) found that a delay may not be necessary, that decrements in anxiety can occur immediately or very soon after exercise. In Morgan's (1973) study, 15 adult males participated in 15 minutes of vigorous running. State anxiety, as measured by the STAI, showed a decrease both at five and 20 to 30 minutes following exercise. Morgan and Bahrke (1972) found that after a vigorous workout 15 adult males showed a significant decrease in anxiety, as measured by the STAI, and this decrease was evident both immediately and at 15 to 30 minutes following exercise. Seeman (1978) also reported decrements in anxiety after exercise performed at 70% of maximum aerobic power for 50 minutes, and these were maintained for up to five hours. In this study, 17 male and 21 female adult volunteers from fitness and jogging classes performed various warm-up exercises followed by a two to seven mile run. Anxiety, as assessed by the four item STAI, decreased immediately after exercise, with a further decrease at 30 minutes. However, Seeman (1978) reports that the immediate assessments were actually made within five to ten minutes following exercise.

The findings from these studies generally are supportive of the position that anxiety may continue to decline for some time after the cessation of exercise. Although an immediate reduction in state anxiety sometimes was obtained, both Morgan and Horstman (1976) and Seeman (1978) noted greater reductions after a delay.

Subject Defined Variables

State anxiety levels prior to exercise

For exercise to reduce anxiety, pre-exercise anxiety must be above basal levels. Studies that have investigated the relevance of pre-exercise anxiety can be differentiated into two types: (1) comparison of individuals classified as high or low on trait anxiety and (2) studies in which pre-exercise levels of state anxiety are measured.

Several studies have assessed differences in normal and highly anxious subjects, partially in response to the Pitts-McClure hypothesis. Pitts and McClure (1971) hypothesized that the blood lactate level of subjects would increase during exercise, resulting in anxiety attacks in anxiety neurotics or highly anxious individuals. This hypothesis has been repeatedly challenged, and researchers have found no evidence to substantiate it, (Gillett, Morgan and Bahrke, 1972; Anderson and Morgan, 1972, (both unpublished studies cited in Morgan, 1973);, and Morgan (1973)). Gillett et. al. (1972) studied the effects of 45 minutes of vigorous physical activity on the anxiety levels of 40 adult males. They found that anxiety, as measured by the STAI, decreased significantly for both normal and highly anxious subjects. Anderson and Morgan (1972) found that after walking a modified Balke treadmill, 17 adult males showed significant decreases in anxiety after exercise. These subjects included those judged clinically anxious. Twelve adult males participated in Morgan's (1972) study. Six were classified as anxiety neurotics, and six as normals. They performed on a treadmill until complete exhaustion. Anxiety decreased equally in both groups. This study was replicated with 17 females. Consequently, it appears there is little support for the Pitts-McClure (1971) hypothesis.

A second set of studies have compared the extent of anxiety reduction after cessation of exercise, where the levels of state anxiety prior to exercise were either high or low. They frequently have reported greater reductions in state anxiety where these levels were high (Wood, 1977; Bahrke and Morgan, 1978: and Stevenson, 1981). In Wood's (1977) study, 62 male and 44 female undergraduates participated in 20 minutes of running covering at least one half mile each. Anxiety was measured by the STAI. The initially high anxious subjects experienced a significant decrease in level of state anxiety immediately after exercise, whereas the initially low anxious subjects experienced a significant increase. Stevenson (1981) partially replicated these findings. She found that a 9.5 minute bicycle ergometer ride covering at least two miles resulted in a significant decrease in anxiety for those classified as initially high in state anxiety. However, those classified as initially low showed either no change or a small increase. Bahrke and Morgan (1978) compared three groups: (1) those who performed 20 minutes of walking at 70% of their self-imposed maximal heart rate, (2) those who meditated for 20 minutes, and (3) those who rested quietly for 20 minutes. While no between group differences were found, there was a significant effect of initial level of state anxiety. Data were collapsed across all three groups, and those classified as initially low showed virtually no change. Morgan (1973) considers this phenomenon as statistical regression of extreme scores towards the mean. In any event assessment is essential to ensure the absence of between group differences on state anxiety level prior to exercise.

Level of fitness

Fitness, the second subject defined variable, has been investigated as to its effects on state anxiety level after exercise (Stevenson, 1980). In Stevenson's study, 44 female undergraduates performed on a bicycle ergometer for 9.5 minutes, covering at least two miles each. State anxiety was assessed by the STAI. Subjects were classified on the fitness variable on a post hoc basis by reference to their heart rates during the exercise. The fitter subjects (ie.; those experiencing lower exercise heart rates) showed a decrease in anxiety following exercise; the less fit showed no change or a small increase.

Unfortunately, Stevenson's (1980) operational definition of fitness confounds fitness with exercise intensity; intensity was defined by reference to external work load (ie., work intensity) rather than in terms of exercise intensity. Consequently, the fitter subjects experienced a lower intensity of exercise. It is not possible, therefore, to conclude from Stevenson's results that fitness is a significant variable mediating the effects of an exercise session on state anxiety levels. However, a clarification of whether fitness does serve a mediating function would prove an important contribution to knowledge.

In summary, there are four identified variables hypothesized to mediate the effects of an exercise session on level of state anxiety following exercise. These are exercise intensity, time of anxiety assessment, level of state anxiety prior to exercise and the individual's level of fitness. To obtain accurate results it is suggested that various exercise intensities be compared, and that assessment be made following a delay after exercise. It is further suggested that subjects' levels of anxiety prior to exercise and their levels of fitness be assessed in order to ascertain relative effects of levels of these variables on benefits gained from exercise.

Clinical Applicability

There are a limited number of studies that have assessed the effectiveness of exercise in alleviating clinical levels of anxiety. Researchers have reported successful intervention with exercise in reduction of anxiety associated with agoraphobia (Orwin, 1973), a situational phobia (Orwin, 1974) and an elevator phobia (Muller and Armstrong, 1975). Orwin (1973) attempted the treatment of agoraphobia with running. He based his treatment on three assumptions. (1) Running is an instinctive response, which is frequently inhibited because, according to Orwin, "patients had become aware that speed might precipitate sensations which they had come to regard as components of the feared panic response, e.g. palpitations". (2) Running provides a cognitively recognizable cause to the physiological response. (3) As in respiration relief (a combination of CO_2 and O_2 inhaled following presentation of feared stimulus), the general increase in autonomic activity would compete with and inhibit the phobic anxiety provoked by the external environment. In Orwin's design, anxiety was inhibited at the moment of its development. The patient ran to the problem situation, to the point of anxiety elicitation, and walked beyond it. A variation was to run through the anxiety provoking situation, decreasing the pace over sessions. For six female and two male patients, sessions ranged from twelve to ninety, over seven to fifty-one days.

At the end all reported no symptoms.

Later, Orwin (1974) presented research on the application of a similar approach with a female patient suffering from a situational phobia, specifically, a fear of high level lavatory cisterns. The patient was informed of the treatment requirements, (1) to run to breathlessness, and (2) to attempt, at that point, to sit near a cistern. The height of the cistern was increased until criterion was reached. At five month follow-up, she remained anxiety-free in the problem situation.

The final example of this procedure is provided by Muller and Armstrong (1975), in treatment of an elevator phobia. These authors employed the running treatment combined with education. The education consisted of increasing the client's knowledge of the dangers in elevators, and the appropriate method of escape in an emergency. Following this she rode elevators regularly. At four months follow-up, this improvement was maintained; avoidance behaviour was completely eliminated.

These "running treatments", however, combine several components of other treatments. Among these components are successive approximations and practice of feared behaviour (Orwin, 1973, 1974; Muller and Armstrong, 1975), and elements of cognitive therapy (Orwin, 1974, and Muller and Armstrong, 1975). While treatments should be combined to afford the greatest possible relief, in research such combination serves only to confound the effects of the components.

Other research on the clinical application of exercise to anxiety reduction has focused on three questions: (1) comparison of exercise to other forms of therapy as a means of reducing state anxiety, (2) the function of exercise in preventing the onset of anxiety and (3) the relevance of fitness to recovery from stress. We will consider the research on each.

(1) Comparison of exercise to other forms of therapy

In order for exercise to be considered a cost effective means of reducing state anxiety, a minimal criterion is that exercise of short duration should be as effective as other forms of treatment in the reduction of state anxiety. The only study to address this question directly was by deVries and Adams (1972).

deVries and Adams (1972) compared the effects of exercise and meprobamate, a commonly used tranquilizer. In a double blind experiment, where each subject served as his own control, twenty normal volunteers were subjected to a series of five treatments. These treatments were presented in random order over a fifteen day period. Each subject "was tested before and after (receiving) (1) 400 mg. of meprobamate, (2) placebo, 400 mg. of lactose prepared in identical capsule form; (3) 15 min. of walking-type exercise at a rate which maintained heart rate at 100; (4)

15 min. of walking-type exercise which maintained heart rate at 120; and (5) control-the subject sat comfortably and read for an equivalent period of time", (p.131). Subjects were pretested on muscular tension measured under undisturbed conditions and under stress. Subjects were posttested immediately following treatment, at 30 minutes following and again after one hour. deVries and Adams (1972) found a significantly greater relaxation effect after exercise than after meprobamate. They concluded:

> Our data suggest that the exercise modality should not be overlooked when a tranquilizer effect is desired, since in single doses, at least, exercise has a significantly greater effect upon the resting musculature, without any undesirable side effects, than does meprobamate. (p.140)

However, the authors did not employ a measure of anxiety. The implications for the present research are unclear as a change in resting musculature may not translate directly into a change in anxiety level.

(2) Function of exercise in preventing the onset of anxiety

Because of the apparently long lasting effects of exercise on anxiety, (Seeman, 1978), Morgan (1982) hypothesized:

> one of the major benefits of regular exercise may reside in its ability to reduce anxiety on a daily basis and, hence, prevent the development of chronic anxiety. (p.131)

Although there is at present no direct test of this hypothesis, convergent support comes from two researchers, Seeman (1978) and deVries and Adams (1972). Seeman (1978) found that following exercise state anxiety remains below baseline for up to five hours. It then returns to baseline remaining asymptotic up to at least 24 hours. deVries and Adams (1972) also noted that reduction in state anxiety following exercise persists for at least one hour. Repetition of exercise may well result in a repeated decrease in state anxiety and thus, the prevention of the development of chronic anxiety.

Other direct tests of Morgan's (1982) hypothesis are required. Such research might proceed by stressing subjects after an exercise period, and comparing their induced anxiety levels to those where no exercise preceded the stress induction. However, most of the research relevant to the question has examined the effects of physical fitness training on psychological variables. Unfortunately much of this research is hampered by empirical flaws, resulting in little more than convergent findings on the psychological effects of physical training. Folkins and Sime (1981) provide detailed criticism of this area by citing two problems which reduce the validity of much of the research: (1) the omission of adequate control groups and (2) the failure to document fitness training effects. It is worthwhile to consider their findings.

The lack of an adequate control group is evident in pre-experimental and quasi experimental designs. Campbell and Stanley (1963) define a pre-experimental study as either the one-shot case study, the single group pretest posttest design or the static group comparison. Such designs are largely uninterpretable as they "do not control for extraneous variables which might produce effects that become confounded with the effect of the treatment variable", (Folkins and Sime, 1981, p.375). While the quasi experimental design is an improvement over the one group pretest-posttest design, it relies on random assignment of treatment to groups. Folkins and Sime (1981) report that this assumption was almost never met in the various studies. "More typically, researchers studied changes in a group (often self selected) exposed to a fitness training program as compared with changes in a convenient group that did not have a fitness training experience" (Folkins and Sime, 1981, p.376). The pre-experimental and quasi experimental designs are more typical of the research in this area than is the true experimental design.

However, the presence of a control group does not guarantee interpretable results. Jasnoski, Holmes, Solomon and Aguiar (1981) used a waiting list control and an independent control group. They were unable to conclude that aerobic training contributed to changes in psychological variables because neither control group received comparable group participation. The authors noted that although psychological changes were evident, "it is important to recognize that they do not indicate whether the changes were due to participation in the program per se or to improvements in aerobic capacity" (p.464).

The second problem, documentation of change in fitness level is of major importance. While there are various forms of fitness, researchers have predominantly limited themselves to cardiovascular fitness. As Folkins and Sime (1981) note, "cardiovascular efficiency has become the best indicator of physical fitness. Studies that demonstrate improvement on cardiovascular criteria presumably have exercise programs of sufficient intensity and duration to create a clinically significant fitness training effect. Other studies without this documentation may have lacked the intensity needed for a training effect and consequently, interpretation of resulting psychological data is problematic" (p.375). Such changes cannot be assumed to follow long term exercise involvement as exercise must be of sufficient intensity and the program of sufficient duration to effect such changes.. As some studies focus on improvement of motor skills, muscle strength and muscle skills, fitness changes can only be certain when adequate pre- and post-program assessments are made of cardiovascular efficiency.

Folkins and Sime (1981) cited five studies of the effects of fitness training on anxiety. All five reported improvement on the dependent variable as assessed by trait anxiety scales. However, only two studies documented changes in cardiovascular fitness. Of these two studies, one was a quasi-experimental design that failed to meet the random assignment assumption (Folkins, 1976), and the other was a pre-experimental design (Young, 1979). Thus, the evidence is at best suggestive and does not permit a differentiation of whether the exercise itself or aerobic fitness mediates any effect.

(3) Relationship between fitness and recovery from stress

The third research question with regard to clinical applicability deals with the relevance of physical fitness to recovery from stress. Increased physical fitness results from repetition of exercise over a long term. The primary index of physical fitness is heart rate at a given work load (i.e., endurance fitness). Three reports address the relationship between physical fitness and recovery from psychosocial stress, (Cox, Evans and Jamieson, 1979; Sinyor, Schwartz, Peronnet, Brisson and Seraganian, 1983; and Keller, 1980).

Cox et. al., (1979) showed that aerobic power is significantly related to the dependent variable, recovery from stress. They assessed subjects' aerobic power, defined by heart rate on a submaximal test. Forty-one male and twenty-nine female undergraduates performed the experimental procedure. Each subject (1) completed a pretest questionnaire designed to measure aggression towards the experiment and experimenters, (2) was frustrated in attempting tasks taken from the Wechsler Adult Intelligence Scale (Wechsler, 1955) and (3) was subjected to verbal abuse. While aerobic power was not related to the magnitude of heart rate response to stress, "subjects with high aerobic power recovered more quickly from the effects of psychosocial stressors than subjects with low aerobic power", (p.162). Sinyor et. al., (1983) subjected two groups of fifteen subjects to stressors (an arithmetic task, a quiz and a color word task). The groups were composed of trained versus untrained individuals. Aerobic training was defined by (1) a questionnaire to assess the extent of participation in aerobic activities, and (2) a bicyle ergometer fitness test. The authors found that though heart rate and subjective arousal levels (as measured by the STAI X-1) increased during the stress for both groups, the trained subjects showed "more rapid heart rate recovery following the stressors and lower levels of anxiety at the conclusion of the session", (p.206). Keller (1980) provides an experimental assessment of the relationship between repeated exercise and changes in physiological and psychological responses to stress. In this study sixty subjects were divided into three groups; an exercise group, a music appreciation group and a meditation group. Each activity was performed four days weekly for ten weeks. Physiological fitness was assessed as step test recovery heart rate. Psychological fitness was assessed as skin conductance, an index of autonomic recovery, during emotionally stressful tasks. These contrived tasks were not defined. These authors found that after the duration of the ten week performance, both the physiological and the psychological tests differentiated between the exercise group and the two controls, indicating that " as physical fitness improves, so does autonomic recovery from psychological stress", (p.119).

In summary, exercise is comparable to other means of anxiety reduction (e.g., meprobamate) in terms of the degree of muscle relaxation, and the duration of this effect (deVries and Adams, 1972). Secondly, exercise is potentially useful as a means of preventing the development of chronic anxiety, (Morgan, 1982). One major side effect of repeated exercise is increased fitness level, and fitness level has been shown to be related to recovery from psychosocial stress. Cox et. al., (1979), Sinyor et. al., (1983) and Keller (1980) have shown that the relationship is a positive one: that increased physical fitness is positively associated with an increased recoverability from psychosocial stress.

Proposed Rationale
for the anxiety-reducing properties of exercise

Many authors have hypothesized mechanisms whereby fitness training could induce changes in psychological variables. Ledwidge (1980) provides an extensive review of these hypotheses on changes in anxiety and depression. Those on anxiety change bear particular relevance to the present investigation. They are elaborated below, subsumed under two headings, based on the proposed physiological and psychological mechanisms involved. We have attempted to relate these hypotheses to changes in anxiety following an exercise session.

(1) Physiological mechanisms

The physiological rationales are derived from three separate areas of investigation into physiological changes associated with fitness training. These areas specifically are concerned with the monitoring of resting muscle action potential level, sleep behaviour and blood lactate levels.

Firstly, several studies found that anxious and depressed individuals exhibit an elevated resting muscle action potential level (MAP), (Malmo, Wallerstein and Shagass, 1953; Martin, 1956; and Whatmore and Ellis, 1959). deVries (1968) found that both acute and chronic exercise reduce the resting muscle action potential level. In his assessment of acute exercise, deVries (1968) had 29 college athletes participate in five minutes of bench stepping onto a twenty inch bench at the rate of 30 steps per minute. This resulted in resting MAP after exercise which was significantly lower for those in the exercise group than for those in the control. Although deVries (1968) study used a normal population, Ledwidge (1980) claims that "there is no reason to doubt that it would have the same effect on anxiety-ridden subjects" (Ledwidge, 1980, p.131).

Secondly, experimental studies have shown that exercise promotes sound sleep. As Ledwidge (1980) reports, several researchers have shown that exercise increases subsequent amounts of slow-wave sleep (i.e., Stage 4 or deep sleep) in cats (Hobson, 1968), in rats (Matsumoto, Nishisho, Sudo, Sadahiro and Miyoshi, 1968) and in man (Baekeland and Lasky, 1966).

Thirdly, "aerobic training reduces the amount of lactate, an acid product of exercise produced by a given amount of work, and research on the biochemistry of anxiety has shown that lactate plays a key role in producing anxiety symptoms", (Ledwidge, 1980, p.131).

(2) Psychological mechanisms

The major psychological rationale reported by Ledwidge (1980) derives from the similarity of symptoms of anxiety and exercise, and the process of cognitive relabelling. Cohen and White (1950) reported that palpitation, fatigue and breathlessness are the most common symptoms suffered by anxiety neurotics. Ledwidge (1980) notes that "strenuous exercise produces the same somatic symptoms" (p.131). Through cognitive relabelling, developing a tolerance for exercise stress might, over time, lead to the tolerance of anxiety symptoms. This is clearly a process related to repeated exercise (fitness training). A notion similar to this, which also relies on a relabelling process was proposed by Orwin (1973, 1974) to account for the more immediate effects of an exercise session. As a result of the similarity of exercise and anxiety symptoms, the anxiety symptoms become attributed to the external work load. While the process is a relabelling one, it relies on the immediately preceding exercise, and cannot be expected to occur in its absence.

The conclusion at this point is that exercise is potentially a valuable means of anxiety management, in terms of both reduction and prevention. However, it is evident that several variables need to be clearly defined and/or accounted for prior to the application of exercise for such purposes. Specifically, these are exercise intensity, fitness level, time of assessment and level of state anxiety prior to exercise.

Purpose of the Experiment

The purpose of the present investigation was to assess the effects of exercise intensity and aerobic fitness on state anxiety. Exercise intensity, as previously defined, refers to the cardiac response (i.e., heart rate) induced by a work load. Aerobic power can be indexed by the cardiac response to a given work load or, conversely, by the work load required to induce a given heart rate. The first hypothesis is based on findings by Morgan and Horstman (1976), and Sime (1977).:

Hypothesis 1: The reduction in state anxiety following exercise will vary positively with exercise intensity (i.e., greater reductions in state anxiety will be associated with the higher exercise intensities).

The mediating function of aerobic fitness, in the exercise-anxiety reduction relationship, has been addressed in only one study (Stevenson, 1980). Unfortunately, aerobic power and exercise intensity were confounded in her design. However, the confounding was in a direction such that higher aerobic power was associated with a lower work intensity. Since she found that anxiety reduction immediately after exercise was greater for fitter individuals, the following tentative hypothesis can be made:

Hypothesis 2: Fitter individuals will experience the greater reduction in state anxiety immediately after exercise.

Several studies have shown that a delay is necessary for extracting the effects of exercise on level of state anxiety (Morgan and Horstman, 1976 and Mitchum, 1976). Others have shown that it is not (Stevenson, 1980; Seeman, 1978 and Morgan, 1973). However, when reductions were reported immediately after exercise, Seeman (1978) found that a delay resulted in an even greater reduction. The third hypothesis is based on these findings.

Hypothesis 3: Any anxiety reduction due to exercise will be greater on delayed assessment than on immediate assessment.

The present design attempted to incorporate the more vigorous aspects of previous experimentation, and introduced some innovations. The main characteristics of the design were: (1) appraisal of physical activity level in terms of exercise intensity rather than work load, (2) the measurement of aerobic fitness both intra-experimentally and conventionally (i.e., by a modification of the Harvard Step Test), (3) the use of a control group which performed the same exercise task as the exercising group, but with no external work load and (4) the assessment of state anxiety both before and immediately following exercise, as well as after a delay.

Method

Subjects:

The subjects were 114 males who were students or employees at Memorial University of Newfoundland. They ranged in age from 16 to 44 years, with a mean age of 21.23 years and a standard deviation of 4.26.

Subjects were recruited through advertisements placed on campus bulletin boards, phone contacts, direct contact, and in-class recruitment. Participation was voluntary, and all subjects were paid. The total time required of each subject was one hour.

Apparatus and Materials:

The exercise portion of the experiment was performed on a Collin's Pedalmate ergometer, with monitoring of heart rate and work load accomplished on the accompanying Collin's monitor. This equipment is designed such that work load may be adjusted manually or automatically. In the present design, the ergometer functioned in the automatic mode. A predetermined heart rate was set, and work load was varied by the ergometer to reach and maintain this rate to within five beats per minute. Subjects were connected to the monitor by an ear clip pulse detector, or by a finger pulse detector which was modified for use with the Collin's monitor.

Anxiety was assessed by self-report with the State-Trait Anxiety Inventory (STAI) forms X-1 and X-2, (Spielberger, Gorsuch and Lushene, 1970). Form X-1 assesses state anxiety (A-State); form X-2 assesses trait anxiety (A-Trait). Both forms consist of twenty statements related to anxiety, with four choices following each. Form X-1 requires the subjects to choose the response that describes their present state. Form X-2 requires them to describe how they generally feel.

The modified Harvard Step Test required a step adjustable for the height of the subject. Adjustments were made according to the criteria given in Table 1, Appendix B.

A stop watch was used to time the duration of the exercise, the rest period and the step test.

All subjects signed a release form relinquishing the experimenter and the university of responsibility for "any accident, hazard or other adverse consequence resulting from participation".

Procedure:

Before subjects committed themselves to the experiment, each was informed of the requirements: twelve minutes of pedalling an exercise bike, twelve minutes of rest, several questionnaires and a one minute step test. They were told that all questions pertaining to the purpose of the experiment would be answered after the procedure was completed. They were informed that all information was confidential. Subjects could discontinue at any time they felt it necessary, and they were informed of this fact.

Each subject was questioned about the presence or history of cardiovascular problems. None of the volunteers indicated any reason why exertion could be dangerous for him. Each then completed the release form.

State anxiety level prior to exercise (PRE-S) was assessed with the State-Trait Anxiety Inventory (STAI X-1), (Spielberger, Gorsuch and Lushene, 1970). Following this, form X-2 of the STAI was administered to obtain an index of trait anxiety level.

The subject then was connected to the Collin's monitor by means of the ear clip and the finger pulse detector. After one minute, the device providing the more stable readings was left in place; the other removed. Subjects in the experimental groups then pedalled to a predetermined heart rate. The control subjects pedalled with no work load other than the normal resistance of the pedals (i.e., minimal watt load).

Subjects were assigned randomly with replacement to one of three experimental conditions or the control group. Twenty-four exercised at a predetermined heart rate of 100 bpm; 29 at 120; 28 at 140; and the final 33 constituted the no-exertion control group.

During the 12 minutes of pedalling, readings were made at one minute intervals of the amount of work performed, in watts. Thus, for each subject there were 12 readings. Work load for each subject was calculated as the mean of the last four readings. The exclusion of the first eight was necessary due to a great deal of fluctuation during the early minutes of the exercise, fluctuations due to the subjects' physiological adjustment to increased work load. The final readings provided stable readings, and yield a reliable indication of each subjects workload at the pre-set heart rate.

The desired pedal speed for the experiment was between 60 and 80 rpm. Subjects were asked to increase speed gradually, until they were within this range, and then to try to maintain it. Some were asked throughout to alter their speed to ensure all subjects pedalled within the same range. (Note: the ergometer automatically adjusts pedal pressure in relation to heart rate in the calculation of work load).

The STAI, form X-1, was administered immediately after exercise (IMMED-S), and again at twelve minutes after exercise (DELAY-S). (This repeated testing design was chosen over a design of one group for each test in order to keep n above twenty per group.) During the intervening period subjects were asked to await the experimenter's return for the completion of the procedure.

Finally, each subject performed the step test, a one minute version of the Harvard step test. Subject height was assessed, and the height of the step was adjusted according to the criteria in Table 1. The test requires the subject to step on a single step at the rate of one step every two seconds, for a total of thirty steps during the minute. Heart rate is obtained for thirty seconds at one, two and three minutes after. The fitness index is the total of the three readings.

Once the procedure was completed, all questions were answered. All subjects were debriefed; the purpose and rationale were explained. Each was informed of the group to which he had been assigned, and thanked for his participation.

Each subject has measures on six variables; four independent and two dependent. The independent variables were (1) initial level of state anxiety, (PRE-S), (2) level of trait anxiety, (3) exertion level, and (4) level of fitness. The dependent variables were (1) anxiety scores immediately following exercise, (IMMED-S) and (2) anxiety scores following a delay after exercise, (DELAY-S).

Results

Preliminary analyses were computed to determine whether the fitness index from the modified Harvard Step Test correlated with fitness assessed intra-experimentally. The latter was indexed by the mean work intensity (in watts) over the last four minutes of exercise. However, since exercise intensity was manipulated deliberately over the three experimental conditions (i.e., excluding the control group), it was necessary to partial out heart rate in assessing the relationship between the Harvard and intra-experimental fitness indices. The partial correlation between the two fitness measures is 0.7234 ($p<.001$), indicating that the indices are comparable in their implications for fitness.

Analysis of the fitness levels across the four groups was computed with regard to the Harvard index. The means are presented in Table 2. (All tables are located in Appendix B.) Analysis of variance failed to yield significant differences ($F(3,100)=1.040$, n.s.), indicating that the groups were comparable with regard to fitness.

For the purposes of the main analyses, fitness levels were assigned to subjects according to the following procedure. Subjects within each group were ranked on each fitness index in turn. The two ranks were then summed and divided by two to produce a mean fitness rank for each subject. Within each exertion group, subjects were divided into high, medium, and low fit groups. An effort was made to achieve equal numbers of subjects within each level. However, unequal numbers in the exertion level groups, and the presence of tied ranks made this impossible. Therefore, fitness level contain numbers as close to equal as was possible.

Further preliminary analyses were computed to assess the effects of level of trait anxiety and level of state anxiety prior to exercise on the exertion level by fitness groupings. Table 3 presents the mean level of trait anxiety for each fitness, exertion and fitness by exertion group. Table 4 presents the results of the analysis on these means. Level of trait anxiety did not significantly vary with either fitness or exertion level nor with their combined groupings. Table 5 presents the mean level of state anxiety prior to exercise for each fitness, exertion and fitness x exertion group and Table 6, the analysis of these levels. Level of state anxiety prior to exercise did not significantly vary with fitness or exertion level nor with their combined groupings. Because the main analyses were performed on the square root transformation of the raw scores the above analyses were repeated using the square root transformations of level of trait anxiety and the level of state anxiety prior to exercise. The results were not different from those already reported. These analyses have been included in Appendix B, tables 12 through 15.

Analysis of covariance is the design of choice because of the correlation of the two independent variables, trait anxiety and level of state anxiety prior to exercise, with the dependent variables. These correlations are presented in Table 7.

Data were analyzed using a two way analysis of covariance design. Specifically, we analyzed the effects of exertion level and fitness level on the square root transformation of state anxiety scores immediately following exercise and state anxiety scores after a twelve minute delay, with trait anxiety and level of state anxiety prior to exercise as covariates. A square root transformation is a standard procedure to reduce heterogeneity in raw scores.

The means of the transformed anxiety scores immediately following exercise for each exertion level, fitness level and their interaction are presented in Table 8, and the results of the analysis of covariance on these means in Table 9. For the analysis of the delayed scores, the means of the transformed scores are presented in Table 10, and the analysis in Table 11.

The analysis revealed one significant effect, the effect of exertion level on the square root transformation of DELAY-S scores, $F=2.7463$, $df=(3,100)$, $p<.05$. Further analysis was performed using Dunnett's test for comparing experimental groups to the control, (Keppel, 1973). The mean difference between those who exercised at 140 bpm and the control mean was significant ($p<.05$). All other control/experimental differences were not significant.

Discussion

To reiterate, this experiment was designed to assess the effects of a short bout of exercise (12 minutes) on level of state anxiety. Specifically, I hypothesized a greater reduction in state anxiety level for individuals exercising at a higher exercise intensity. I also expected level of fitness to mediate this effect in terms of speed of recovery from exercise stress (ie. that fitter individuals would show a more rapid recovery and hence, a significant reduction in level of state anxiety immediately following exercise). Finally, I hypothesized that any anxiety reduction due to exercise would be greater on a delayed assessment than on the immediate assessment.

The level of exercise contributed significantly to the anxiety reducing properties of the exercise session. Compared to the control group, only subjects exercising at the most intense exercise level (140bpm) experienced a significant decrease in anxiety. (This was evident only after a delay.) The control group experienced conditions identical to the experimental groups except that the level of exercise intensity was zero. This manipulation allows the conclusion that the difference in exercise intensity is an important variable to consider when assessing the effects of exercise on anxiety levels. It is unlikely that this finding is due to chance given the number of analyses computed in the study (i.e., only 13 tests of significance were performed). This finding is supported by Morgan and Horstman (1976), who found that state anxiety significantly decreased 20 to 30 minutes after moderate and heavy exercise but not after light. Higher exercise intensity involves greater production of ATP aerobically: higher heart rate, increased blood pressure, body temperature, and respiration rate, as well as increased local muscle activity and fatigue. Any or all of these components may account for the decrease in anxiety following exercise.

The finding is directly contrary, however, to that of Andres, Metz and Drash (1978) who found only the lowest intensity of exercise to effect a reduction in anxiety. An important methodological distinction between the Andres et. al., (1978) design and the present might explain this discrepancy. This study and Morgan and Horstman's (1976), unlike that of Andres et. al., (1978), imposed a delay between exercise and time of anxiety assessment. The effect of time of assessment will be discussed later. However, the only study comparable to this assessment of exercise intensity is Morgan and Horstman's (1976). The conclusion, based on their study and the present one is that greater submaximal exercise intensity results in a greater decrease in level of state anxiety as measured some minutes following exercise.

Level of fitness did not exhibit the hypothesized effect on state anxiety reduction following exercise (ie. the fitness hypothesis was not confirmed). Immediately following the session, fitter individuals did not show a greater reduction in state anxiety compared to the less fit. There are two components to this hypothesis: (1) a difference between groups due to fitness, and (2) the presence of state anxiety reduction immediately following exercise. The only other study to address the first component was Stevenson's (1980). Her findings do not agree with the present ones; she found a significantly greater decrease in level of state anxiety following exercise for the more fit individuals than for the less fit. As we have already noted, Stevenson's (1980) design confounds fitness with exercise intensity. In her study, the independent variable was work intensity. This definition results in lower exercise intensities experienced by the fitter individuals. The studies are, therefore, not comparable. However, a problem with the present design in assessing the effects of fitness is the division of subjects into groups on an a posteriori basis. Such a procedure may produce groups not sufficiently different from one another in fitness to exhibit differences after a moderate intensity exercise session (140bpm).

The second component of the fitness hypothesis is that of effects being evident immediately after exercise. This study found no immediate effects. However, Morgan and Bahrke (1972), Morgan (1973) and Stevenson (1980), reported reductions in anxiety immediately following exercise. This discrepancy cannot be accounted for.

The fitness hypothesis was based, in part, on studies that have found that fitter individuals show a greater speed in recovery from psychosocial stress (Cox, Evans and Jamieson (1979); Keller (1980) and Sinyor, Schwartz, Peronnet, Brisson and Seraganian (1983)). Extending these findings to exercise research results in the hypothesis of a more rapid recovery from exercise stress for the fitter individuals. However, the design of this experiment was such that speed of recovery could not be assessed adequately because only two data points were used. As a result, the conclusion, with regard to the effect of fitness level on reduction in state anxiety following exercise, is that the fitness levels representative of the subjects in this study exhibited no significant influence on the reduction in state anxiety immediately following exercise.

As hypothesized, after the twelve minute delay, subjects showed greater reductions in level of state anxiety than they did on the immediate assessment (only those who exercised at 140 bpm). In fact, it was on this assessment alone that subjects exhibited a significant reduction in level of state anxiety. The reason(s) for this are not evident, but it is possible that a decrease in somatic arousal over time maximizes anxiety reduction.

The requirement of a delay in extracting the exercise intensity effects has already been reported by Mitchum (1976) and Morgan (1973). As well, Seeman (1978) found that although decreases were evident at five minutes following the cessation of exercise, further decrements were evident at 30 minutes. Other findings consistent with those presently obtained come from Morgan and Horstman's (1976) study of the time course of anxiety during exercise. Their findings, of an increase in state anxiety during exercise followed by a significant decrease at the tenth minute after exercise, suggest that a delay of a least ten minutes is necessary for extracting the effects of exercise. These findings suggest that anxiety reduction may be related to recovery from exercise stress. That is, as exercise stress dissipates, so do anxiety symptoms. The difference being that physiological changes induced by exercise return to basal level while anxiety symptoms return to baseline and beyond. To assess the questions posed by the findings related to hypotheses 2 and 3, a design parallel to Morgan and Horstman's (1976) and Seeman's (1978) may be employed, involving repeated assessments of anxiety levels and level of physiological arousal during and for some time following exercise. Specifically, this would allow us to assess the time course of recovery from exercise for fit and unfit individuals.

In summary, a moderate level of exercise (140bpm) was found to lead to a significant decrement in anxiety, which was evident after a delay following exercise. An individual's level of fitness was not found to affect the benefits in the form of anxiety reduction derived from exercise.

These findings have implications for the usefulness of exercise as a method of alleviating clinical levels of anxiety. They are based on a conservative estimate of the effects of an exercise session; the subjects were from a university population, one in which levels of anxiety are not expected to approximate clinical levels. Subjects suffering from clinical levels of anxiety may be expected to show greater relief. In any event, there is no reason to suppose that they should show a qualitatively different response to exercise (Morgan, 1973).

Other considerations must be taken into account before advocating exercise as a means of anxiety reduction in clinical populations. These considerations relate to the efficacy of exercise compared to the currently applied methods and to the optimal level of exercise for this purpose. Meditation has been shown to be equally effective (Bahrke and Morgan, 1978) as has rest (Bahrke and Morgan, 1978 and Morgan, Roberts and Feinerman, 1971). In fact, the present findings suggest that immediately after treatment, these methods may be expected to provide greater relief as the delay inherently necessary in using exercise is unnecessary with these treatments. As well, exercise requires careful monitoring by the patient to ensure that an adequate and safe heart rate is achieved and maintained over some minutes. In other words, the patient must be fully aware of the method of administration of exercise-as-treatment. Until such time as we can prescribe clear guidelines, it may be unwise to prescribe exercise as such a procedure

There are clear benefits, however, in using exercise over these more conventional methods. Repeated exercise has a side effect of improved physical fitness level (Cooper, 1978). Morgan (1976) hypothesized that repeated exercise may well lead to the prevention of the development of chronic anxiety. Finally, Keller (1980) has shown that repeated exercise not only differentiates between exercisers and meditators on physiological variables (ie. step test recovery heart rate), but on psychological measures as well (ie. skin conductance).

More research is needed to ascertain the relative time courses and efficacy of exercise and conventional methods of anxiety relief (eg. meditation, relaxation training, drug therapy). Adequate comparisons of the methods are necessary to assess their relative contributions to immediate relief and the duration of relief following a single session (dosage). Long term studies must assess their abilities to maintain efficacy over treatments, their susceptibility to the development of side effects, and the necessity and feasibility of maintaining the treatment for extended periods. To prescribe exercise over and above these more conventional methods is not yet warranted.

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Appendix A

Glossary of Terms

<u>Exercise</u> is defined as physical activity of at least moderate intensity and/or duration. It involves the utilization of one or more among three energy systems: two anaerobic (adenosine triphosphate-phospho creatine or ATP-PC, and lactic acid) and one aerobic system. For exercise of high intensity and short duration, (eg. maximal effort of up to 10 seconds duration) only the ATP-PC system is used. ATP-PC is also used at the beginning of exercise of lower output. In cases of lengthier periods of exercise ATP-PC must be replenished. The lactic acid system serves such a function. According to Bouchard, Thibault and Jobin (1981), the lactic acid system is important for exercise of up to three minutes. Thereafter, for longer duration exercise like running, jogging, cycling, ATP-PC is replenished mainly through the aerobic system. Bouchard et. al. (1981) describe these systems as acting synergistically.

Although the use of the aerobic system also implies the use of the anaerobic systems, the distinction between the aerobic and anaerobic systems provides a basis on which type of exercise can be differentiated. In the present investigation, exercise refers to the predominant use of the aerobic system, in the form of a twelve minute cycling session.

Fitness as used for the purposes of this thesis is synonymous with aerobic fitness. Aerobic fitness is indexed either by the level of physiological response to a given work load, or by the maximal work load a person can endure.

Anxiety: Anxiety is manifested in two forms, state anxiety and trait anxiety. Discussion of these is provided by Spielberger, Gorsuch and Lushene (1970) in their development of the State-Trait Anxiety Inventory (STAI). Definitions used here are based on their formulation of the concepts.

State anxiety refers to "a transitory emotional state or condition of the human organism that is characterized by subjective, consciously perceived feelings of tension and apprehension, and heightened autonomic nervous system activity. A-States may vary in intensity and fluctuate over time." (Spielberger et, al., 1970, p.3)

Trait anxiety, relative to state anxiety, is more pervasive and fluctuates less. It refers to "relatively stable individual differences in anxiety proneness" (Spielberger et. al., 1970, p.3). An individual's level of trait anxiety is stable over time and affects the level of state anxiety experienced. An individual found to have a high trait anxiety score on the STAI form X-2 would likely respond to an anxiety provoking situation with elevations in the score on the state anxiety scale, form X-1, of a greater magnitude than an individual of lesser trait anxiety.

Appendix B

Tables

Table 1. Height of step for given subject height.

Subject height	Height of step
< 5 ft	12"
5' to 5'4"	14"
5'4" to 5'8"	16"
5'8" to 6'	18"
> 6'	20"

Table 2. Mean step-test fitness level for each exertion group.

	Exertion Group			
	Control	100bpm	120bpm	140bpm
$\bar{x}$	113.42	105.04	112.55	116.07
n	33	24	29	28

Table 3. Means of trait anxiety level for each group.

		EXERTION LEVEL				
		Control	100bpm	120bpm	140bpm	$\bar{X}$
F	H	37.64	37.25	30.75	31.50	34.41
I		(11)	(8)	(8)	(10)	(37)
T	M	38.00	33.38	35.40	31.78	34.78
N		(10)	(8)	(10)	(9)	(37)
E	L	34.25	35.88	35.73	34.78	35.10
S		(12)	(8)	(11)	(9)	(40)
S	$\bar{X}$	36.52	35.50	34.24	32.64	34.77
		(33)	(24)	(29)	(28)	(114)

Table 4. Analysis of variance: Trait Anxiety by exertion level and fitness level.

Source	SS	df	MS	F	
Exertion	246.736	3	82.245	1.670	N.S.
Fitness	7.928	2	3.964	0.080	N.S.
ExF	347.315	6	57.886	1.175	N.S.
Within	5024.652	102	49.261		

Table 5. Mean level of pre exercise state anxiety for each group.

		EXERTION LEVEL				
		Control	100bpm	120bpm	140bpm	$\bar{X}$
F	H	34.18	34.00	33.88	29.70	32.86
I		(11)	(8)	(8)	(10)	(37)
T	M	34.40	30.25	31.80	31.89	32.19
N		(10)	(8)	(10)	(9)	(37)
E	L	29.17	37.13	32.27	34.11	32.72
S		(12)	(8)	(11)	(9)	(40)
S	$\bar{X}$	32.42	33.79	32.55	31.82	32.60
		(33)	(24)	(29)	(28)	(114)

Table 6. Analysis of variance: Level of state anxiety prior to exercise by exertion level and fitness level.

Source	SS	df	MS	F	
Exertion	52.736	3	17.579	0.369	N.S.
Fitness	10.060	2	5.030	0.106	N.S.
ExF	492.626	6	82.104	1.724	N.S.
Within	4858.539	102	47.633		

Table 7. Correlations between the covariates and the dependent variables.

	IMMED-S	DELAY-S
Trait Anxiety	.4113 *	.5879 *
PRE-S	.4736 *	.6586 *

* p<.001

Table 8. Means of the square root transformation of immediate state anxiety scores for each group. (n)

		EXERTION LEVEL				
		Control	100bpm	120bpm	140bpm	$\bar{X}$
F	H	5.67	5.69	5.31	5.29	5.49
I		(11)	(8)	(8)	(10)	(37)
T	M.	5.93	5.46	5.69	5.75	5.72
N		(10)	(8)	(10)	(9)	(37)
E	L	5.28	5.43	5.90	5.60	5.55
S		(12)	(8)	(11)	(9)	(40)
S	$\bar{X}$	5.61	5.53	5.67	5.54	
		(33)	(24)	(29)	(28)	

Table 9. Analysis of covariance for the immediate scores.

Source	SS	df	MS	F	
Exertion	.5706	3	.1902	.6425	N.S.
Fitness	1.2070	2	.6035	2.0388	N.S.
ExF	2.2882	6	.3814	1.2883	N.S.
Within	29.6020	100	.2960		

Table 10. Means of the square root transformation of delayed state anxiety scores for each group.

		EXERTION LEVEL				
		Control	100bpm	120bpm	140bpm	$\bar{X}$
F	H	5.60	5.44	5.03	4.98	5.28
I		(11)	(8)	(8)	(10)	(37)
T	M	5.69	5.12	5.41	5.06	5.34
N		(10)	(8)	(10)	(9)	(37)
E	L	5.19	5.32	5.47	5.40	5.34
S		(12)	(8)	(11)	(9)	(40)
S	$\bar{X}$	5.48	5.29	5.33	5.14	
		(33)	(24)	(29)	(28)	

Table 11. Analysis of covariance for the delayed scores.

Source	SS	df	MS	F	
Exertion	1.0561	3	.3520	2.7463	p<.05
Fitness	.1344	2	.0672	.5243	N.S.
ExF	1.3425	6	.2237	1.7454	N.S.
Within	12.8190	100	.1282		

Table 12. Means of the square root transformation of trait anxiety scores for each group.

		EXERTION LEVEL				
		Control	100bpm	120bpm	140bpm	$\overline{X}$
F	H	6.08	6.09	5.53	5.58	5.83
I		(11)	(8)	(8)	(10)	(37)
T	M	6.15	5.75	5.91	5.62	5.87
N		(10)	(8)	(10)	(9)	(37)
E	L	5.83	5.98	5.94	5.87	5.90
S		(12)	(8)	(11)	(9)	(40)
S	$\overline{X}$	6.01	5.94	5.82	5.68	5.87
		(33)	(24)	(29)	(28)	(114)

Table 13. Analysis of variance for the trait anxiety scores

Source	SS	df	MS	F	
Exertion	1.807	3	0.602	1.712	N.S.
Fitness	0.102	2	0.051	0.145	N.S.
ExF	2.415	6	0.402	1.144	N.S.
Within	35.884	102			

Table 14. Means of square root transformation of pre-exercise state anxiety scores for each group.

EXERTION LEVEL

		Control	100bpm	120bpm	140bpm	$\overline{X}$
F	H	5.83	5.81	5.79	5.43	5.71
I		(11)	(8)	(8)	(10)	(37)
T	M	5.84	5.48	5.62	5.64	5.65
N		(10)	(8)	(10)	(9)	(37)
E	L	5.37	6.02	5.64	5.82	5.67
S		(12)	(8)	(11)	(9)	(40)
S	$\overline{X}$	5.66	5.77	5.67	5.62	5.68
		(33)	(24)	(29)	(28)	(114)

Table 15. Analysis of variance for the pre-exercise state anxiety scores.

Source	SS	df	MS	F	
Exertion	0.291	3	0.097	0.267	N.S.
Fitness	0.064	2	0.032	0.089	N.S.
ExF	3.646	6	0.608	1.673	N.S.
Within	37.056	102	0.363		