EFFECTS OF EXERCISE ON STRESS: A META-ANALYSIS

by

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A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF PHYSICAL EDUCATION

in

THE FACULTY OF GRADUATE STUDIES
School of Physical Education and Recreation

We accept this thesis as conforming
to the required standard

UNIVERSITY OF BRITISH COLUMBIA
January 1991

ROSEMARY VAN STAVEL, 1991
Abstract

Physical exercise is frequently prescribed by clinicians and researchers as an effective stress reduction technique. There has been some research to support this assertion, however the research has been varied in its methodological rigor. The design problems, variations in exercise programs, and the use of a wide range of psychological measures have made results difficult to interpret. Additionally, the psychological benefits and underlying change processes have not been clearly delineated. The purpose of this study was to conduct a meta-analysis of the research in this area in an attempt to answer specific questions regarding the role of exercise in stress reduction. This meta-analytic approach was chosen because it permits the quantitative integration of findings of several studies and consideration of the variables that may influence the variance in study outcomes. The effectiveness of exercise as a treatment for stress, the type of exercise that was most beneficial, and the type of individual who gained the most from the exercise intervention was examined.

The 61 effect sizes, which were calculated from 24 studies included in the meta-analysis, were coded along with other variables considered important. Study components such as design type, stress level, type of exercise program, program length, frequency of exercise sessions, attrition rate, psychological measure, composition of sample, gender, and
study type were coded as independent variables. Effect size was the dependent variable. Analysis of variance revealed that exercise was an effective stress reducer, stressed people gained a greater stress reduction effect than minimally stressed people, and there were no differences between trait and state anxiety reduction from pre- to post-exercise program. In addition, a one-way ANOVA indicated that there was a significant difference between program lengths. Examination of the means revealed that an 8- to 12-week program was most effective in reducing stress. Although there was a greater effect size for unpublished studies than published studies, the pattern of change for each study type was similar.

The significance of these results and recommendations for future studies are discussed.
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Acknowledgements

I am eternally grateful to Paul Calderhead, dear friends and research supervisor whose support and encouragement in my darkest hours made it possible for me to continue my thesis.

This study would not have been possible without the guidance and incredible patience of Dr. Bonita Long. I would like to express appreciation to Dr. Long, research supervisor, for sharing her extensive knowledge of the stress concept and exercise, for her support and helpful suggestions throughout my thesis.

I would also like to thank Dr. R. Schutz for his generous donation of time to discuss the methodology and statistical matters. His patient guidance was invaluable in clarifying the meta-analytic approach and statistical analysis.

I would also like to thank Dr. K. Coutts for his support and comments on my thesis.

My acknowledgegment would not be complete without a warm thank-you to Sasha whose smile and antics helped to bring laughter into my most stressful times.
Introduction

In the last decade, exercise as a prescription for improved physical and psychological health, in particular stress, has received increasing attention in the health field (Berger, Friedmann, & Eaton, 1988; Goldwater & Collis, 1985; Hughes, Casal, & Leon, 1986; Morgan, 1985). The psychological benefits of exercise are widely espoused in popular health, fitness, and psychological literature (Folkins & Sime, 1981; Morgan & Goldston, 1987; Sachs, 1982). Although the mechanisms involved in the physiological benefits of exercise have been well documented (Barnard & Anthony, 1980; Bjurstrom & Alexious, 1978; Nelson, Jennings, Esler, & Korner, 1986), the psychological benefits and underlying change processes have not been as clearly delineated (for reviews see Folkins & Sime, 1981; Hughes, 1984; Ledwidge, 1980; Mihevic, 1982).

Research on the psychological benefits of exercise has shown conflicting outcomes (Berger & Owen, 1987; Blumenthal, Williams, Needels, & Wallace, 1982; Hughes, 1984; Nagy & Frazier, 1988; Setaro, 1985). Thus the efficacy of exercise as a treatment modality for stress is uncertain. Because traditional reviews in this area have failed to systematically and quantitatively analyze the research in order to establish generalizations concerning exercise and stress, the purpose of this study is to integrate research on exercise as a treatment for stress through meta-analysis. The analyses will attempt to answer the following questions: Is exercise an effective
treatment for stress reduction? Is exercise more effective in treating people who report greater stress levels than people with less stress? What type of exercise is the most effective stress reducer?

Psychological Effects of Exercise

An early review by Ledwidge (1980) focused mainly on proposed hypotheses for the effects of aerobic exercise on mood states. He did not review and integrate the results of studies in order to deduce whether exercise had a positive effect on mood. His paper was largely concerned with the hypothesis of the study. From his review, he concluded that exercise did have a positive effect on mood. However, because the purpose of this study is to review outcomes, Ledwidge's review will not be described in detail.

A major review by Folkins and Sime (1981) focused on theory and research that related exercise to improvements in psychological variables such as mood, self-concept, and work performance among normal as well as selected clinical populations. They identified the design problems, variations in exercise, and the use of a wide range of psychological variables that made results difficult to interpret. In addition they found that much of the research relating exercise programs to affect focused on the stress emotions, especially anxiety. Most of the studies reviewed showed that fitness was associated with improvements in mood states. This effect was more pronounced with participants who were
distressed or physically unfit at the outset. However, only one of those studies was a true experimental design. They also found that exercise training interventions were frequently offered to individuals who were interested in participating in an exercise program. This selection bias is a threat to the validity of these studies and confounds comparisons with control groups.

With regard to personality, Folkins and Sime (1981) found that self-concept was most consistently associated with improvements in physical fitness. There was also evidence of the positive effects of exercise on cognitive function. Exercise appeared to bolster cognitive performance (e.g., performance of mental tasks) during and after physical activity. Folkins and Sime also examined theoretical perspectives which could offer explanations for the effect of exercises on psychological functioning. They explored somatopsychic theories, psychological viewpoints and a cognitively orientated model. The latter was the most satisfactory in their opinion. "...the fitness training effect may be viewed as a self-regulation (coping) process that enhances adaptive interactions with a person’s environment" (p. 374). In Lazarus and Folkman’s (1984) stress and coping theory, coping behaviour is antecedent to emotional reactions and regulates its form and intensity. Thus exercise may be considered a self-regulatory strategy in adapting to stressful situations.
Since Folkins and Sime's review there has been an improvement in some of the study designs (e.g., control groups, measuring fitness levels pre- to post-test) and attempts to examine the effects of exercise on particular psychological variables (e.g., Roskies et al., 1986). Further examples of improvements in study designs are mentioned in the literature review.

In a more specific review, Mihevic (1982) examined the effects of acute and chronic exercise on anxiety and the effects of chronic exercise on depression. He concluded that vigorous, single bouts of exercise were associated with reductions in state anxiety or tension. Both normal and anxious individuals displayed a reduction in anxiety 20-30 minutes post exercise. However, there were only a few experimental studies of the chronic effects of exercise on state anxiety. There was some evidence that chronic running decreased muscular tension and self-reported state anxiety for male participants. The studies also showed that a vigorous exercise program was associated with decreases in depression for people who were clinically depressed. The latter part of his review examined biochemical/physiological explanations or hypotheses for the effects of exercise on affective states. He identified processes such as lactate metabolism and endorphins as factors that may mediate the effects of exercise on anxiety. Mihevic did not explain how he derived his conclusions or what criteria for inclusion was used for the
articles reviewed. He did however mention that little information was provided about the fitness levels of participants and the changes in fitness levels after an exercise program.

Hughes' (1984) integrative review of controlled experiments examined the relationship of habitual aerobic exercise and mood, personality, and cognition. This review, like Folkins and Sime's (1981) review, did not use a quantitative analysis to establish generalizations about the issues under examination, nor did it document a systematic analysis of the research being reviewed. The conclusions were that exercise improved self-concept, however there was little evidence for claims that exercise improved anxiety, depression, body image, personality, or cognition. Hughes noted that there were over 1,000 articles written on the psychological effects of exercise as well as several reviews of the effects of exercise on anxiety, depression, personality, cognition, and work performance. Hughes suggested that "future research should examine the individuals and the disorders that are most likely to experience psychological benefits from exercise, the types of exercise that are most beneficial, and the proposed mechanisms for the psychological benefits" (p. 66).

In summary, researchers have been studying the effects of exercise on a wide range of psychological variables, including stress, without arriving at definitive conclusions regarding
the beneficial influence of exercise on mood or stress (Abood, 1984; Blumenthal et al., 1982; Dorinsky, 1984; Hughes et al., 1986).

Although Ledwidge (1980) and Folkins and Sime (1981) agree that exercise is associated with improvements in mood states, Folkins and Sime (1981) also considered exercise to be a self-regulatory strategy in adapting to stressful situations. This view supports Mihevic's (1982) conclusion that acute and chronic exercise decreased state anxiety and muscular tension. Hughes (1984) disagreed with the above reviewers and noted that there was little evidence for the claims that exercise improved mood or anxiety.

Effects of Exercise on Stress

The burgeoning of stress research results from a growing concern for the health of the population on the part of governments and organizations (Cox, Gotts, Boot, & Kerr, 1988). This has been shown by the increase in stress management and health promotion programs within the workplace and other communities. Physical fitness programs are common components of stress management and health promotion in the workplace (Pelletier, 1986). Although the effectiveness of exercise programs as a treatment for stress and psychological health is not well supported with scientific research, the rationale for its effectiveness exists due to personal experiences (Cooper, 1978; Sheehan, 1978) and limited research support (Long, 1984; Long & Haney, 1988).
A frequently reported observation of researchers, clinicians, and lay people is that many individuals experience an enhanced feeling of well-being following physical activity (Dorinsky, 1984; Mellon, 1985; Sachs & Buffone, 1984; Sheehan, 1978). These observations have provided the basis for the prescription of exercise for stress reduction (Byrd, 1963; de Vries, 1968; de Vries & Adams, 1972; Dorinsky, 1984). However, research on effects of exercise on stress is varied in design, definitions of exercise and stress, and the degree to which the participants are stressed prior to intervention.

The findings from several studies suggest that exercise of an endurance nature reduces anxiety in stressed adults (Dorinsky, 1984; Long, 1984; Long & Haney, 1988; Steptoe, Edwards, Moses, & Mathews, 1989; Wilson, 1985). These studies prescribed exercise 3 times per week for an average of 8 weeks. The exercise programs were found to be as effective as other stress-management interventions (i.e., progressive relaxation and stress-inoculation training). There are other data to suggest that exercise has positive effects on trait anxiety and/or mood (tension) in participants (students and adult volunteers) who are not particularly stressed (Abood, 1984; Berger et al., 1988; Eby, 1985; Moses, Steptoe, Mathews, & Edwards, 1989).

Studies that examined recovery from stressful situations, comparing fit and unfit groups, have found that the fit groups physiologically (i.e., pulse and blood pressure) recover more
rapidly (Holmes & Roth, 1985; McGilley & Holmes, 1988). However, there was little difference between the fit/unfit participants posttreatment psychological measure (i.e., a questionnaire testing subjective arousal; Holmes, 1982). The participants were subjected to stressful cognitive tests and it was found that the fit groups indicated smaller cardiovascular (blood pressure and heart rate) and some subjective responses (anxiety measure) to psychological stress. Moreover, Morgan (1979) and de Vries (1968) and their associates have consistently demonstrated that acute exercise reduces state anxiety and muscle tension.

Thus some research showed a decrease in stress with exercise as a treatment modality, whereas other research showed no significant effects regarding the efficacy of exercise as a treatment for stress (Nagy & Frazier, 1988; Setaro, 1985; Stern & Cleary, 1982). In addition, research on exercise as a stress treatment had design limitations and used a wide range of psychological variables, thus results are often difficult to interpret. Furthermore, these studies frequently targeted a population that was not particularly stressed or anxious (Bahrke & Morgan, 1978; Berger & Owen, 1987). In spite of the contradictory findings there is a strong belief that exercise has a positive effect on stress (Sachs & Buffone, 1984). Therefore it is important that this belief be corroborated by a quantitative, integrative review of research on this phenomena.
In order to answer the question is exercise an effective treatment for stress, reviews of the research conducted to date have been inconclusive. However, these reviews have had several limitations:

(a) They have mainly examined published research.
(b) They have not been quantitatively rigorous and did not document their methodology so that their review could be replicable.
(c) They have not examined outcome research—comparing treatment packages for stress/anxiety.
(d) They examined the proposed mechanisms that mediate between the exercise and the psychological benefits without any "proof" of the assumptions being made.

In order to combat some of the previous limitations, this study incorporates a meta-analytic approach, which integrates research that examined the effectiveness of exercise as a treatment for stress. Meta-analysis is defined as "the statistical analysis of summary findings of many empirical studies" (Glass, McGaw, & Smith, 1981, p. 21). Meta-analysis can provide a quantitative analysis in order to answer specific questions regarding the efficacy of exercise as a treatment for stressed individuals. The variables (e.g., type of exercise, treatment length, type of leadership for treatment, stress level, design type, publication) that influence the outcome of studies are examined in order to
answer specific questions regarding the effects of exercise on stress. The following questions were posed: Is exercise an effective treatment for stress reduction? Is exercise more effective in treating people who report greater stress levels than people with less stress? What type of exercise is the most effective stress reducer?
Literature Review

Stress and Exercise

Today most people believe that exercise has positive effects on all aspects of health. In the last decade, exercise as a prescription for improved physical and psychological health, in particular stress, has received increasing attention in the health field (Berger et al., 1988; Goldwater & Collis, 1985; Hughes et al., 1986; Morgan, 1985). The National Institute of Mental Health formulated the following consensus statements:

Physical fitness is positively associated with mental health and well-being. Exercise is associated with the reduction of stress emotions such as state anxiety. Long-term exercise is usually associated with reductions in traits such as neuroticism and anxiety. Appropriate exercise results in reductions in various stress indices such as neuromuscular tension, resting heart rate, and some stress hormones. Current clinical opinion holds that exercise has beneficial emotional effects across all ages and in both sexes (Morgan, 1985, p. 95).

These statements assume that research has conclusively verified that exercise is an effective stress management technique. Yet this is not so because the research outcomes are varied. There is little consistency in research designs, length of treatment, type and intensity of exercise, and population and anxiety type among the studies.
population and anxiety type among the studies.

The demands of our ever changing world prevent few to escape the stresses and strains of daily living (Abood, 1984; Berger & Owen, 1987). Professionals are prescribing exercise for physiological and psychological problems (Hales & Travis, 1987). Although the mechanisms involved in the physiological benefits of exercise have been well documented (Barnard & Anthony, 1980; Bjurstrom & Alexious, 1978; Nelson, Jennings, Esler, & Korner, 1986), the psychological benefits and underlying change processes have not been as clearly delineated (for reviews see Folkins & Sime, 1981; Hughes, 1984; Ledwidge, 1980; Mihevic, 1982).

This stressful era has seen a growing concern for the health of the population on the part of governments and employment organizations (Cox et al., 1988). As a result, there is an increase in stress management and health promotion programs within the workplace and other communities. Physical fitness programs are common components of stress management and health promotion in the workplace (Pelletier, 1986). However the effectiveness of exercise programs as a treatment for stress and psychological health is not well supported. The rationale for its effectiveness is provided mainly by anecdotal studies (Sachs & Buffone, 1984) and some research support (Long, 1984; Wilson, 1985). Yet the psychological benefits of exercise continue to be widely espoused in popular health, fitness, and psychological literature (Folkins & Sime,
1981; Morgan & Goldston, 1987; Sachs, 1982). Strasser (1989) states that "Exercise prescriptions are now commonplace. Psychiatrists prescribe exercise to reduce nervous tension;.... Exercise, however, does make people feel better and thus has a positive effect on health. This helps counter the increasing influence of stress. .... As a countermeasure, business has started stress-reducing programs using exercise programs" (p. 110). These statements appear in an occupational health and safety journal as irrefutable fact. Given the need to find a variety of effective coping strategies for the stresses and strains of daily living, clinicians are prescribing exercise as a viable coping strategy.

However research has not produced definitive answers regarding the effect of exercise on stress and anxiety mood states. Studies to date have had varying results in examining the relationship of exercise and stress. There are many methodological limitations in the studies within this area. The studies vary in terms of research designs and approaches as well as using a variety of paper-and-pencil instruments for anxiety. Therefore, there is a need to find answers to some basic questions common to most of these studies. A method of integrating this information and answering some common research questions is meta-analysis. Before elaborating on the meta-analytic approach, a definition of stress and exercise and the types of studies available in this area must be delineated.
There are five key categories into which the studies can be assigned: the effects of single bouts of exercise on state anxiety, the effects of an exercise program on people's mood, the effects of an exercise program on people who were not particularly stressed, the effects of an exercise program on people who were stressed, and the physiological and psychological responses of fit and unfit people to stressors.

Definition of Stress

The words stress and anxiety are often used interchangeably in research on stress or anxiety (Spielberger, 1972). Stress within the context of this review is considered to be a transactional, process-oriented phenomena (Lazarus & Folkman, 1984). Lazarus' transactional view of stress is a holistic perspective and takes into account the particular life experiences of the individual, their personal value system and the environmental factors interacting together to create a specific appraisal of a specific event. In this model, anxiety is one of many emotions which may result due to the perception of threat within the situation. This model is useful because it purports that the experience of stress is a subjective perception of a situation. Thus stress may be assessed with self-report measures of emotions such as anxiety and tension.

Two main features of Lazarus and Folkman's (1984) theory includes the individual's assessment process of primary appraisal (what is the significance of this situation to the
done about this situation now or later?). Should the situation be assessed as being a threat, a loss/harm, or a challenge to the person; emotions such as fear, anxiety, depression or anger may be evoked, whereas the emotions evoked by challenge are apt to be more hopeful of a successful outcome. The individual’s response to the primary appraisal may favour an emotion-focused and/or problem-focused coping style. Emotion-focused coping is oriented toward regulation of emotions and problem-focused coping is oriented toward doing something to relieve the problem (Lazarus & Folkman, 1984).

Exercise in this study is assumed to be used by the individual in several ways. It may be a method of coping with the stress/anxiety emotions evoked by a situation; an emotion regulator (i.e., decrease muscle tension, breathe deeply). However it can also be used as a method of solving a problem (i.e., thinking of solutions while running, a time to ‘cool down’ before speaking with another about a conflictual situation).

Anxiety is an emotional state which can vary in intensity and is aroused by the person’s perception of a threat or danger to the self (Sarason, 1985). This threat or danger does not necessarily reflect the objective reality but the person’s notion of what is dangerous to the self. Spielberger (1972) defined anxiety as "an unpleasant emotional state or condition which is characterized by subjective feelings of tension, apprehension, and worry, and by
state or condition which is characterized by subjective feelings of tension, apprehension, and worry, and by activation or arousal of the autonomic nervous system" (p. 482). He also referred to state anxiety as the emotional reactions that are evoked in people when they perceive a situation to be threatening. Therefore an anxiety state exists at a particular moment in time, and at a certain intensity depending on the amount of threat perceived. Trait anxiety would reflect the relatively enduring individual tendency to appraise situations as threatening. These two psychological constructs are measured in Spielberger’s State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970). There are other paper-and-pencil instruments which also measure either state or trait anxiety.

Therefore, in this study stress will be operationalized by self-reported measures of anxiety and tension. Given that people are the best judges of their emotional state at any particular moment. Thus studies focused on all levels of anxiousness, with the exception of anxiety disorders (as defined by DSM III; American Psychiatric Association, 1980) that would be treated in a psychiatric/clinical setting, are considered appropriate for the study.

**Definition of Exercise**

Exercise is viewed as any physical activity which taxes the physiological systems of the individual, and the conditioning effect desired will dictate the specific type of
activity (Fox, Bowers, & Foss, 1988). There are usually three areas which individuals want to improve: muscular strength and endurance, flexibility, and cardiovascular endurance. The latter is the most commonly prescribed as treatment for stress (Dorinsky, 1984; Sinyor et al., 1983; Taylor et al., 1985). Cardiovascular endurance is achieved by the rhythmic contractions of large muscle groups over a period of time—aerobic exercise. Aerobic exercise develops the ability of the respiratory and cardiovascular systems to efficiently deliver oxygen to all the working muscles over a prolonged period of time. Forms of aerobic exercise are jogging/running, swimming, brisk walking, cross country skiing, rowing, and cycling (Fox et al., 1988). FITT is an acronym which indicates the best way in which to achieve optimum aerobic conditioning effects (Stewart, 1982).

F frequency of exercise - 3 to 5 times per week.
I intensity of exercise - 60% to 70% (moderate to intense range) of the person’s maximal heart rate.
T time of exercise - initially 15 minutes, working toward 30 minutes.
T type of exercise - endurance activities, with some strength and flexibility.
FITT also prescribes the optimal manner in which to gradually proceed in any other type of exercise program.

Although many of the studies reviewed prescribed cardiovascular endurance exercise as treatment for stress, in
this meta-analysis exercise encompassed a more general definition. Exercise studies were included if they contained any physical activity that involved large muscle groups over a period of at least 15 minutes for a minimum of 4 weeks. This would allow for the examination of whether a particular type of exercise was (e.g., walking vs weight training) was best suited as a treatment for stress.

Effects of Single Bouts of Exercise

Earlier studies examined the effects of a single dose of exercise on state anxiety. Morgan (1973) described a series of investigations in which he and colleagues explored the possibility that vigorous physical activity could be a useful "coping strategy" for reducing anxiety. The participants were categorized as 'normal' or highly anxious depending on their score on the STAI prior to participating in the exercise. The findings revealed a significant decrease in state anxiety between the pre-exercise and post-exercise test on State-Trait Anxiety Inventory (STAI). Bahrke and Morgan (1978) compared the influence of acute physical activity, meditation, and a quiet rest session on anxiety. A significant reduction in anxiety occurred for each treatment. Morgan hypothesized that because each treatment appeared to be effective, exercise did not influence state anxiety but an activity as a 'time-out' effect did. Morgan and Horstman (1976) conducted an experiment in which two samples of 30 men walked to exhaustion on a motor driven treadmill. The men used 80% of their maximum aerobic
power. State anxiety as measured by STAI before, during, and after the exercise. Anxiety increased significantly in early exercise, reached a peak about half way through, and then decreased rapidly. The state anxiety levels had dropped below original levels, 10 minutes after exercise was completed. These results applied to the the "normal" as well as the clinically anxious participants.

Wood (1977) studied the state anxiety levels of 62 college males and 44 college females following a 12 minute run. There was a significant decrease in state anxiety for the males and no significant change for the females. He gives no explanation for the gender differences but he does discuss his findings in terms of high and low anxious groups. He divided the females and males into high and low anxious groups and examined their anxiety scores pre- to post-run. The high anxious group did reduce their state anxiety, whereas the low anxious group increased their anxiety yet still remained within the normal range. He concluded that a single bout of exercise did reduce anxiety in anxious students but that the arousal level of the low anxious students was increased during exercise.

Abood (1984) examined the effects of acute physical exercise on state anxiety and mental performance of college women. State anxiety was assessed by the State-Trait Inventory and the digits backwards subtest of the Wechsler Adult Intelligence Scale (Wechsler, 1958) was used to measure mental
performance. Participants were selected who scored in the upper and lower 30 percent on the STAI. Participants from each of these conditions were randomly assigned to either the experimental or control groups. The experimental group completed the state anxiety form of STAI before and after bench-stepping 30 times a minute for 5 minutes. The control groups were asked to rest for 5 minutes in a comfortable chair between the pre- and post-anxiety test. Both the experimental and the control groups had lower post-anxiety scores than on the pre-anxiety test. State anxiety however was not significantly reduced in the highly anxious women, but there was a trend in that direction. Abood suggested that one interpretation might be that the intensity of exercise was not sufficient. The low anxious women experienced a significant increase in their state anxiety, yet their anxiety levels remained within normal range. Abood (1984) attributed this to a heightened arousal state after a short bout of exercise.

de Vries (1968) examined the situation from a slightly different perspective. His investigations looked at the effect of exercise on muscular tension. The tension as measured electomyographically, was significantly reduced following vigorous exercise. de Vries and Adams (1972) investigated the effects of single doses of exercise and meprobamate (a tranquilizer drug) as to the effect on muscular tension. The participants who exercised had greater decreases in muscle tension than the group who received the tranquilizers.
In summary, not all of these investigations had a control group nor did they examine exercise as a treatment over a period of time. The differential effects of intensity and type of exercise on anxiety cannot be examined in a single bout of exercise. The results were inconclusive. There was no significant differences in decrements in state anxiety for the control and experimental groups; males showed a decrease in anxiety whereas females did not; and the less anxious females increased their state anxiety. These studies are also limited in that they do not examine trait anxiety, whereas state anxiety is an emotional reaction of an intensity which is generated by the situation of the moment. In examining the effect of a single bout of exercise on state anxiety, the researcher is receiving a very biased look at an emotional reaction as it taps only the experimental situation.

The researchers in the following section have attempted to look at the ramifications of an exercise program upon mood. The exercise programs examined were at least 4-weeks in length and followed the prescribed fitness guidelines for the particular program offered. Thus giving an extended time frame in the investigation of exercise on anxiety.

Effects of an Exercise Program

Folkins, Lynch, and Gardner (1972) were forerunners in examining the effects of an exercise treatment program upon mood. They submitted 44 junior coed college students to a semester jogging program and found improvement in their
depression and physical fitness. These researchers concluded that the students who were in poorest physical and emotional health appeared to benefit the most from the program.

Folkins (1976) examined the effects of an exercise treatment program on the mood of high coronary risk males. The exercise group participated in 3 exercise classes per week for 12 weeks. After the program, he looked at the physical and psychological changes from pre- to post-exercise for both the exercise group and the control group. Anxiety and depression scales from the "in general" version of the Multiple Affect Adjective Checklist (Zuckerman & Lubin, 1965) were used. Significant decreases in anxiety and depression were found only in the exercise group.

Researchers shifted from examining the effects of an exercise program versus a single bout of exercise to examining the effects of an exercise program for people who were not particularly stressed. The focus of this research was an extension into the realm of the participant's psychological state.

**Effects of exercise program on the minimally stressed.** Eby (1984) investigated the effects of an aerobic exercise program on trait anxiety as measured by STAI and depression as measured by Zung Self-rating Depression Scale (Zung, 1965). Graduate and undergraduate students were solicited and randomly assigned to 4 groups (delayed treatment, weight training, jogging, and a combination of weight training and
jogging). The treatment was 6 weeks of individual programming in each group with little to no group interaction. The aerobic group showed significant improvement from pre- to post-test in the estimation of their maximum oxygen uptake but there was no significant change in the anxiety and depression scores. There was a trend toward significant change within each exercise group, the lowest posttest cell means occurring in the following order; aerobic group, combination group, weight training group, and delayed treatment group.

A study by Blumenthal et al. (1982) assessed the effects of aerobic exercise on the psychological functioning of a nonclinical sample of healthy middle-aged adults. There were 16 participants in both the experimental and control groups. The experimental group participated in a 10-week walk-jog program, whereas the matched control group maintained their sedentary lifestyles. The participants completed a battery of psychological tests (Profile of Moods; McNair, Lorr, & Droppleman, 1971; STAI; and a retrospective questionnaire regarding self-perceptions of change) pre- and post-exercise program. Examination of test scores revealed that the exercise group improved significantly in their state-trait anxiety scores and the tension, depression and fatigue subscales of the Profile of Moods scores, compared with the control group. The control group remained the same or showed deterioration on certain scores. They concluded that there was a potential utility of regular aerobic exercise in promoting psychological
health in normal adults.

McGlynn, Franklin, Lauro, and McGlynn (1983) studied the effect of aerobic conditioning and induced stress on state-trait anxiety, blood pressure, and muscle tension. They investigated the effects of a 14-week individualized aerobic conditioning program. The participants were drawn from an undergraduate population. The experimental group participated in an aerobic class and were sedentary prior to joining the class, whereas the control group was formed from health sciences classes. Baseline measures were taken before the treatment program began on all of the variables being investigated. At the end of the 14-week program, participants from both groups were retested and also subjected to a stressful intervention. The conditioned group showed a significant increase in cardio-vascular endurance (as measured by Sharkey's (1979) step test). There were no significant differences between groups for state and trait anxiety but there were significant differences in the electromyographic measurements.

Nagy and Frazier (1988) hypothesized that sedentary participants would have positive gains on moods as an outcome of a short-term (15 week) exercise program, compared with participants who exercised regularly prior to the 15-week exercise program. They also examined the relationships among exercise, locus of control, and self esteem. Mood states were assessed using the Profile of Mood States (POMS) before and
after treatment. The pre- and post-measures on the mood states were not significantly different for either group, indicating that the hypothesis that a sedentary group of people starting an exercise program would have positive gains on moods was not supported. The locus of control and the self-esteem scores showed minimal variation between the two groups.

Simons and Birkimer (1988) however found a mood enhancement effect in their experimental group, compared with the control group. They also used the POMS measure for mood. Mood improvement was significantly different in the following subscales of the POMS; anger, anxiety, and confusion. Depression was decreased significantly only from pretest to follow-up. The participants in the 8-week aerobic class also showed an improvement in their fitness levels. Three months after the program, the participants continued to show an improvement in their mood states but the extent of exercise over that period was not measured. Despite changes in the mood state measures there were no changes in the group’s locus of control measures.

Hughes et al. (1986) argued that many previous studies were poorly designed or used inappropriate measures that affected the outcomes. They tested the effect of a 12-week exercise program on the mood of sedentary men who were "free of psychopathology" in a randomized cross-over design. The participants were randomly assigned to either an exercise program or a control group (maintenance of sedentary
lifestyle) and then switched to the converse condition. The exercise was nonsocial and of moderate intensity. The exercisers improved in the treadmill duration test but not the maximum oxygen uptake test. The total mood or any of the POMS subscales improved more during the exercise period than during the control period. They concluded that exercise alone is insufficient to produce psychological benefits, "i.e., either psychopathology, socialization, or a training effect must be present for exercise to produce psychological benefits" (p. 359).

The results continue to be mixed with regard to the efficacy of exercise as a treatment for anxiety. The quality of the research improved in that researchers tested fitness improvements within their studies, and examined differences between types of exercise. However, the participants were often drawn from a population that might have definite values concerning exercise because they came from health science courses or had been about to join a fitness class. The participants in these studies were not particularly stressed. Perhaps participants with greater stress levels would result in different outcomes.

**Effects of exercise program on the stressed.** A controlled, randomized design that accounts for a socializing effect was conducted by Moses et al. (1989). The study compared the effects of two, 10-week aerobic training programs of differing intensities on mood and mental well-being with
those of a credible attention-placebo condition. Sedentary adults from the local population were assigned to one of four conditions: high exercise (60-90% maximum HR), moderate exercise (60% of maximum HR), attention-placebo (strength and flexibility exercises), and wait list. The participants were tested pre- and post-exercise program on fitness and psychological measures. POMS was used to evaluate the effects of the experimental conditions on psychological well-being. A series of scales were developed for this study for the evaluation of perceived coping ability. Cooper's 12-minute walk-run test showed an orderly progression of improvement for the aerobic training groups, with the greatest change in high exercise and minimal change in the attention-placebo condition. There was a significant improvement in the subscales of tension/anxiety and confusion of the POMS with the moderate exercise condition but not the high exercise or attention-placebo conditions. The perceived coping ability showed an improvement from pre- to follow-up testing in the moderate exercise condition.

Steptoe et al. (1989) replicated their previous study with an anxious group of adults from the general population. The psychological effects of a moderate aerobic exercise program were compared to an attention-placebo condition. The STAI was added to the psychological measures. There were significant improvements in aerobic fitness in the moderate exercise group as compared to the attention-placebo condition.
Significant group differences existed post-training on POMS tension/anxiety, confusion, depression and on perceived coping abilities. No significant differences were shown between groups post-training on tests of trait anxiety. There were main effects of session, with session as the within-subject factor (ANOVA), in trait anxiety. This reflected the general decrease in trait anxiety that was reported by both groups. The psychological effects were maintained on the 3-month follow-up.

Long (1984) compared the effectiveness of an aerobic conditioning program (jogging), stress inoculation training, and a wait list control in the treatment of chronic intermittent stress. The stressed participants were randomly assigned to one of three groups. The treatment program was conducted in two waves—a time-lagged crossover design. The wait list group was randomly assigned to either an exercise or stress inoculation group after the initial program was completed. The fitness and stress evaluations were done pretest, posttest and 12-week follow-up. Participants in the jogging program were placed on a progressive walk/jog regime and were encouraged to gradually increase their distance and decrease their time. These participants did experience significant decrements in state and trait anxiety (as measured by STAI) which were maintained or improved in a 3-month follow-up.

Wilson (1985) also examined exercise as a possible
treatment for reducing the stress response in nurses. She argues that nurses are usually stressed due to their occupational difficulties. Thirty-four nurses were randomly assigned to a 16-week aerobic exercise program or a control group. Aerobic exercise consisted of an individualized progressive walk/jog program 3 times per week. All participants had their baseline levels of fitness, physiologic-biochemical and psychological taken prior to the start of the program and once again post program. The results indicated that the exercise group increased their oxygen uptake, decreased their A.M. resting heart rate and systolic blood pressure. State anxiety was significantly reduced in the exercise group but not trait anxiety (as measured by STAI) when compared to the control group. The physiologic measure of stress was found to be equal between the exercise and control groups. The Zung (Zung, 1965) measure for depression also showed a reduction in the exercisers’ depression levels. In her concluding arguments, Wilson states "since the results of this study have shown that exercise was stress reducing, hospital administration and nursing management should consider exercise an important component in the planning of a stress management program" (p. 205).

Setaro (1985) compared the effectiveness of different combinations of aerobic exercise and group counseling in a 10-week treatment program of anxiety and depression. Participants anxiety and depression as measured by scales #2 and #7 on the
Minnesota Multiphasic Personality Inventory (MMPI; Hathaway & Mckinley, 1943) were tested pre- and post-program. Participants entering the treatment program were experiencing mild to moderate depression and anxiety (T score range of 60 through 75 on scales #2 and #7 of the MMPI). Anxiety in this instrument is supposed to measure trait anxiety. One hundred and fifty participants were randomly assigned to either cognitive group counselling and aerobic dance, aerobic dance, cognitive group counselling, cognitive group counselling and non-aerobic activity (arts & crafts), non-aerobic activity and no treatment groups. The data were subjected to a multivariate analysis of variance followed by a priori orthogonal contrasts. The results indicated that (a) the effect of all treatments were greater than no treatment; (b) cognitive group counselling had a greater effect than either aerobic or non-aerobic conditions in the treatment of depression and anxiety; (c) aerobic exercise was more effective than the non-aerobic condition in the treatment of depression but not anxiety; (d) the combination of cognitive group counselling and either aerobic or non-aerobic activity was more effective in the treatment of depression but not anxiety than group counselling alone; (e) the combination of cognitive group counselling and aerobic exercise was more effective than group counselling and non-aerobic activity in the treatment of depression but not anxiety. Setaro suggests that aerobic exercise in the treatment of anxiety differs according to the type of anxiety
treated. He suggests that state anxiety might be more affected by aerobic exercise than trait anxiety. He concludes that as depression and state anxiety appear to respond to exercise treatment it should be incorporated into occupational and industrial settings.

Long and Haney (1988) compared two stress reduction interventions (aerobic exercise and progressive relaxation exercises) in the treatment of stress. Fifty stressed, sedentary, working women were randomly assigned to either group for an 8-week treatment program. The participants identified at least two persistent work-related stressors and scored 5 or above on Walk’s (1956) Tension Thermometer. The instruments used to measure stress pretest, posttest and follow-up were the STAI Trait Anxiety Inventory; The General Self-Efficacy Scale (Sherer et al., 1982); and the ways of Coping Checklist (Lazarus & Folkman, 1984). The exercise group participated in a progressive walk-jog program while the relaxation group practiced Berstein and Borkovec’s (1973) progressive muscle relaxation. Both groups reduced their trait anxiety from pre- to posttreatment with further reductions at 8-week follow-up. Their self-efficacy increased from pre- to posttreatment and was maintained at follow-up. The coping strategies of the participants did not significantly change at either posttreatment or follow-up. The researchers determined that the study tended to support the general conclusion that participation in aerobic exercise or progressive relaxation
programs could have potential in helping decrease anxiety and increase self-efficacy in sedentary, stressed working women.

Once again there are mixed results regarding the effectiveness of exercise in treating stressed people. The descriptive statistics indicate that the participants within an exercise program did show some improvement but the contrast between a control group or a comparison group showed no significant differences in improvement. However, the quality of the research has improved. Moses et al. (1989) and Steptoe et al. (1989) designed studies that controlled for socialization effects, and examined differences in exercise intensities and fitness improvements.

The final group of studies to be reviewed investigated the differences between fit and unfit peoples' responses to stressors. This particular line of research examines the physiological and psychological effects of an exercise program before and after stressing the participants.

**Fit/unfit people's reaction to stressors.** Like McGlynn et al. (1983), some researcher decided to approach the problem of the effectiveness of exercise as a stress management technique from the perspective of viewing how fit and unfit people respond to stressors. In McGlynn's study the conditioned group did not show a significant increase in blood pressure as was the case in the control group. After being subjected to a stressful cognitive task, both groups did show significant increases in muscle tension and state anxiety, although the
control group's mean increases were markedly higher than the conditioned group's means.

Keller and Seraganian (1984) conducted two studies to determine the influence of aerobic fitness level on autonomic reactivity to psychosocial stress. The first study used 45 men who were trained, untrained, or were in training to test their autonomic reactivity (as measured by lability in electrodermal activity) to two speeded mental tasks designed to induce psychosocial stress. The men were tested at 3-week intervals over 9-weeks. At the initial test the trained men showed faster autonomic recovery from this stress than did the untrained or training men. In the following tests the 3 groups were similar in their autonomic responses. The second study employed 60 participants who were randomly assigned to 10-week aerobic exercise, meditation, or music appreciation programs. Once again the participants were subjected to two psychosocial stressors that were administered at week 2, 6, and 10 of the treatment program. Participants improved significantly in their fitness levels and also showed faster recovery in the electrodermal response to the stressors. The researchers inferred that the quicker autonomic recovery perhaps allows the aerobically fit person to cope more effectively with emotional stress.

Holmes and Roth (1985) examined the effects of a stressful task on high and low fit subjects. Sitting quietly during a baseline period their pulse rate and levels of
subjective arousal were assessed. Analyses showed that task performance resulted in general increases in pulse rates and subjective cognitive arousal, and subjective somatic arousal. The high-fit group however evinced smaller pulse rate increases in response to stressors than did the low fit group. Both groups were similar in the subjective responses to the stressors. Holmes and Roth concluded that their results were consistent with a growing body of research which indicates that aerobic fitness is associated with reduced physiological reactivity to psychosocial stress. McGilley and Holmes (1988) conducted a similar study of high- and low-fit participant's reactivity to stress. They found that the high fit group evinced reliably smaller cardiovascular responses (blood pressure and heart rate) to a stressful cognitive test and also reported smaller increases in cognitive and somatic arousal than the low-fit group.

Investigating the effectiveness of exercise as a stress reducer from this particular perspective adds to the confusion of the results to date. Although people's cardiovascular responses might differ between fit and unfit people, their psychological responses do not always differ. This could be due, in part, because one's perception of stress plays a large role in one's psychological stress responses (Lazarus & Folkman, 1984). If stressors depend on a person's perception of what is or is not threatening/harmful, then contrived stressors within an experimental situation might not
necessarily be stressful to all the participants.

Summary

In summary, although most studies reviewed evinced some change on stress measures, not all measures showed a significant change. The researchers reported that there had been some effect, "a trend in the given direction" no matter how small the change. Perhaps that, in part, determines the popularized view that exercise is an effective stress reducer. A great deal of inconclusive research exists in this area. Given the need to evaluate the effect of exercise on stress since exercise is being widely prescribed as effective, it would be a waste to continue adding to this body of inconclusive knowledge. Instead the present information must be integrated in order to provide some answers and provide direction for future research. Although each study asks its own particular questions, there is an underlying pattern to the questions being asked. This evolving pattern appears to be concerned with the following questions: is exercise an effective stress reducer? what type of person benefits most from exercise? and which type of exercise is of most benefit in stress reduction? The meta-analytic approach allows the researcher to integrate the present body of studies in order to answer these questions and also to consider the variables which will influence the variance in study outcomes.

Meta-analysis

In 1977, Glass introduced a quantitative method
(meta-analysis) for integrating the findings of many research studies on a common theme. He coined the term meta-analysis to convey the idea that there were ways to quantitatively summarize many individual studies. Meta-analysis is defined as "the statistical analysis of summary findings of many empirical studies" (Glass et al., 1981, p. 21).

Traditionally, researchers relied upon narrative reviews for assessing the accumulated knowledge of a specific topic in a given field. The purposes of reviews vary according to the researchers' primary interest and may focus on assessing new substantive and/or methodological developments in a given field; verifying existing theories; synthesizing knowledge from various fields of research; or inferring generalizations about issues from a set of studies examining those issues. The latter purpose for a review is called an integrative review. Although each of these reviews have methods, techniques, and procedures that guide the researchers' assessment of the knowledge being reviewed, these reviews are not refined or rigorous enough to adequately capture the overall meaning of a large body of studies (Jackson, 1980). Glass et al. (1981) contend that "the reviewer is even less able to absorb the sense of a hundred research studies than the observer is able to scan a hundred test scores and, without reliance on statistical methods, absorb the sense of their size and spread, and correlations" (p. 14).

The evolution of integrative reviews has been molded by
the rapid growth of research in the fields of education, behavioural and social sciences, exercise and health. Research has resulted in many divergent outcomes on any one topic within a given field. Due to the diversity of research outcomes on a specific hypothesis, Glass (1976) thought the attempts to make sense of the proliferation of the same body of knowledge must be of a rigorous and quantitative nature. He thought that this approach would be able to show the regular patterns discernable within a body of studies in a similar area of research.

Brief History of Meta-analysis

The early roots of meta-analysis began in the field of agricultural experimentation. The field of agricultural experimentation had several problems in achieving adequate experimental studies and outcomes on pertinent topics. Large lots of land were needed for experimentation, and, as this was not possible, smaller lots were used for several similar studies. There were also difficulties in maintaining the same environmental variables and agronomic practices when attempting to gather information on identical agricultural questions. The researchers thus had to find a way in which to interpret the large body of single study designs, viewing similar questions with differing results (Bangert-Drowns, 1986). At first the statistical problem (at least in similar cases) might appear to be similar to that of the analysis of a single replicated trial, however the situation was usually
more complex, and the uncritical application of methods appropriate to single experiments may have led to erroneous conclusions. Therefore researchers sought to modify the ordinary analysis of variance in order to find the general underlying principles and patterns of several different results (Yates et al., 1938).

In 1931 Tippit answered the problem by suggesting methods to test the statistical significance of results combined from separate experiments. Researchers, such as Fisher (1932), K. Pearson (1933), and E. S. Pearson (1938), also sought ways to combine probability values from tests of significance. Yates and Cochran (1938) developed methods to estimate the mean effect and variability of a specific treatment studied at various agricultural centers.

Wilkinson (1951) suggested a method of using the "meta-analytic" attitude of agricultural research for the social sciences. He proposed that the binomial distribution could be used to determine the expected number of significant results given a true null hypothesis since study results are either significant or nonsignificant.

The investigation of methods for integrating results from different studies continued and in the seventies at least four investigators had worked independently on complementary efforts to resolve the issue of combining results from different studies. Schmidt, Hunter, and colleagues (1973, 1976, 1978) examined criterion validity for several small
sample independent studies using the same or similar measures. Rosenthal (1978) researched methods of aggregating results of independent studies by combining their probability values. Glass (1976) proposed a statistical analysis using effect size (a common value for each empirical study) to examine the summary findings of each study. This became commonly known as meta-analysis.

Advantages of Meta-analysis

Meta-analysis has two major advantages over other integrative reviews. First, it provides a set of procedures for decision-making during a literature review, and second, it applies statistics to quantitative representations of study outcomes.

The set of procedures for doing meta-analysis are analogous to those conducted in any primary research and includes; the selection of questions or hypotheses, definition and measurement of the variables being considered, sampling, data analysis, and reporting/discussing the results. The sampling in meta-analysis may be less prejudgemental than other reviews, in that a priori opinion on the quality of research methodologies is not necessary. For instance, it does not disqualify dissertations because they have not been published. Meta-analysis considers the question of methodological weaknesses in the sample studies and their relationship to study results as an posteriori question (Glass et al., 1981). The data analysis and reporting part of the
review, seeks to provide useful general conclusions from the examination of different studies concerned about a similar problem. The small differences which occur within the studies under review are ignored in the process of making generalizations about the overall patterns found within those studies. Thus the general conclusions can give practical information about the utility of certain treatments. The interactions occurring within each individual study might also be acknowledged in the concluding remarks of the review, should the reviewer think it pertinent to the topic under examination. Meta-analysis is quantitative in that it uses statistical methods for extracting and organizing information obtained from a large sampling of studies. Table 1 provides a summary of the procedural steps suggested by Glass (1976) and Glass et al. (1981).

When these steps are meticulously followed, other researchers could duplicate the steps in order to check or verify the results of the meta-analysis. The replicable nature of this systematic approach makes the meta-analytic review the closest possible to a well-designed original experimental research.

Limitations of Meta-analysis

All analytic approaches to integrative reviews have difficulties in the application of the approach and meta-analysis is no exception. The difficulties of the meta-analytic approach are as follows:
Table 1

**Procedural steps in meta-Analysis**

1. Identification of the problem
2. Literature search - thoroughness of search and basis for inclusion or exclusion of studies
3. Coding the characteristics of each study
4. Quantifying study findings - effect size calculation
5. Statistical analysis of effect size data
6. Interpretation of results
7. Reporting steps 1 through 6 in a review paper.
(a) It cannot assess evidence which does not directly pertain to a given topic. When the topic under investigation has been indirectly studied, the evidence cannot be woven together with other study results. For instance, if the topic is "Does treatment Y lessen the effects of stress in stressed adults?" There may not be studies directly examining this question, but there may be studies on the effects of Y on stress in mice. The latter information cannot be woven together with the effects of Y on stress in humans. The meta-analytic approach can be used to evaluate the results within each set of studies concerning the treatment Y in stressed humans only.

(b) Each primary study included in the meta-analysis might use different instruments to measure the dependent variables. The constructs of the dependent variables may be different even though they are used under a single topic. For instance, the outcomes of various studies on the effects of exercise on stress could include anxiety, tension, depression, coping abilities, and biochemical levels. Each of these dependent variables will be measured by a different metric instrument. There are also different instruments to measure the same dependent variable. These concerns are part of the controversial "apples and
oranges" argument against the Glassian meta-analytic approach. Glass' rebuttal to these concerns states that there is no need to compare studies that are the same because the findings would be similar, within statistical error. The purpose of the meta-analytic approach is to find the patterns within different studies on the same topic. He further argues that pooling the findings of studies 1 through 10 is similar to pooling of results from persons 1 through 50 in a single research experiment as the subjects are as different and as much alike from each other as studies are different from each other (Glass et al., 1981).

(c) It cannot be used to infer which variables within each study, on a given topic, caused the differing results. Even when all the studies within the review have used good experimental designs, the variables identified from the studies cannot be systematically manipulated as in a primary experiment.

(d) There are no clearly documented standards for sample sizes when using statistics for the meta-analysis. Similarly to primary research, the meta-analysis needs a large sample size if multivariate statistics are to be used. However the number of cases may be greater than the number of studies being reviewed because Glass suggested using an "effect" as the unit of analysis and each study may have more than
one effect. "An effect is defined as any analysis within a study of a given treatment and outcome at a given time of measurement" (Jackson, 1980, p. 453). Each study could have several analysis of a given treatment and its outcomes.

(e) There may be difficulties achieving valid and reliable coding of the characteristics of the primary studies to be analyzed. This problem is not great if the set of studies to be coded is relatively small and can be done by a single investigator. There is also a selection bias not only by the coder but by the primary researcher as there tends to be systematic differences among results of research appearing in a particular type of journal vs. theses vs. books. Glass views these difficulties as part of the differences which occur in research designs of all qualities. Each study can have its own particular weakness (i.e., weak in measurement but otherwise strong; weak only in internal validity or data analysis.

Summary

The meta-analytic approach guides the researcher's decision making processes in quantitatively integrating the studies' results. In areas of study where there has been considerable research, but conflicting findings, meta-analysis is a suitable research procedure to use to attempt to identify
the variables which may cause the ambiquity. Exercise and stress is such an area, therefore meta-analysis is an appropriate approach.
Method

Literature Search

The literature search included a computerized search of Psychological Abstracts, Medline, Medlars, Eric Index, Dissertations Abstract International and a manual search of the Oregon Microfiche List. The references in relevant research were used in tracing additional material. Only studies on adults of both sexes, aged 18 and over, in the area of 'effects of exercise on stress/anxiety' were searched for. The studies that were included in the review were either experimental/or quasi-experimental, and used a validated self-report measure of the state/trait construct of anxiety. The validated self-report measures were instruments which had been frequently used to measure anxiety, possessed face and construct validity and test-retest reliability. The instruments used to measure anxiety in the studies included in the meta-analysis were the: POMS, STAI, Multiple Adjective Checklist (MAACL), MMPI (scale #7), Taylor Manifest Anxiety Scale (Taylor, 1953) and Test Anxiety (Sarason, 1972). The POMS and STAI were used in 19 of the 24 studies in the meta-analysis. Another criteria for inclusion related to the type of exercise program--an exercise program had to involve a recognized fitness prescription (Stewart, 1982) over a period of at least 4-weeks. Studies that (a) examined the effects of one bout of exercise, (b) included only physiological measures of stress, (c) assessed individuals of differing fitness
levels and then responses to stress, or (d) investigated psychiatric populations, were excluded.

Of the 61 studies identified that examined the effects of exercise on stress, only 24 met the criteria for inclusion. Three dissertations could not be obtained. Other studies were excluded because they did not meet the following criteria: (a) 7 were of a single session design, (b) 2 examined a psychiatric population, (c) 2 were investigating the effects of exercise on adolescents, (d) 3 examined the effects of exercise using a procedure which was similar to a single session design, (e) 6 investigated the effects of exercise on type A personalities, (f) 7 examined fit and unfit participants' physiological and psychological responses to stressors, and (g) 7 investigated the physiological and psychological responses of participants pre and post a stress event. See Appendix A for a list of the studies that were included.

Design and Procedures

The next step involved identifying and coding the potentially important parameters of the meta-analysis. The variables that could influence the variance in study outcomes were identified and coded so that these variables could be considered in analysing the effect data. The 24 studies yielded 61 effect sizes. In further discussion of the variables included in the meta-analysis, the effect sizes will be the \( N \) for each variable level.
**Study type.** Whether the research study was published or unpublished was noted as some meta-analytic researchers consider this to be a factor in the quality of the research. There were 40 published study effect sizes and 21 unpublished study effect sizes.

**Design.** The type of design used in the study was coded as within-group change (e.g., pre- to post-design; \( N = 33 \)) and contrast change (e.g., between groups design; \( N = 28 \)).

**Gender.** The participants' sex was noted as it could influence the anxiety response to the exercise treatment. Studies were coded as all female (\( N = 15 \)), all male (\( N = 4 \)) and both (\( N = 42 \)).

**Composition of sample.** The type of population the participants represent (e.g., student or non-student population) could also be a factor in their stress reduction after participating in an exercise treatment program. Therefore, studies were coded as students (\( N = 22 \)), students and faculty (\( N = 2 \)) and non-students (\( N = 37 \)).

**Stress level.** The stress level was integral to this study as it was investigating whether exercise was more effective for greater stressed or less stressed people. There is some indication that stress level may influence the anxiety response to the exercise intervention, therefore studies were coded as minimally stressed (\( N = 37 \)) and stressed (\( N = 24 \)). The studies of stressed people, advertised for people who felt stressed and had specific criteria for stress levels. While
minimally stressed people were determined because they did not report anxiety prior to entering the research study.

**Psychological measure.** The instruments used to measure state or trait anxiety (dependent variables) were coded as trait \( N = 32 \) and state \( N = 29 \) anxiety. The tension category of the POMS, the state subscale of STAI, MAACL, and Test Anxiety were coded as state anxiety. The trait subscale of STAI, and the #7 subscale of the MMPI were coded as trait anxiety.

**Program length.** The length of the exercise intervention was coded as 6- to 8-weeks \( N = 18 \), 8- to 12-weeks \( N = 29 \), and 12 plus weeks \( N = 14 \). The length of an intervention has been known to play a part in psychological treatment programs.

**Type of exercise treatment.** Whether the type of exercise had an effect on people's stress levels was one of the research questions examined. The types of exercise were therefore coded as aerobic \( N = 54 \), non-aerobic \( N = 2 \), aerobic and weights \( N = 3 \), and aerobic and counselling \( N = 2 \).

**Frequency of exercise session.** The number of times the participants exercised each week was coded as 3 times per week \( N = 50 \) and 3 or more times per week \( N = 11 \).

**Leaders.** The type of leadership for each exercise intervention and the qualifications of the leaders were noted. This information was coded as trained \( N = 33 \), no training \( N = 1 \), leaderless \( N = 8 \), and not specified \( N = 19 \). The
majority of trained leaders were trained in exercise management (N = 21) and 3 studies (N = 12) mentioned psychological training as well as exercise management training of the leaders.

Attrition rate. The drop-out rate was coded as greater than 20% (N = 13), less than 20% (N = 23), and not mentioned (N = 25). The drop-out rate from an exercise intervention could influence the effect of exercise on stress level.

Follow-up. Whether or not the studies included some form of follow-up assessment was coded as Yes (N = 18) or No (N = 43). Follow-up is one way of noting whether the benefits of an exercise program has continued after completion of program.

Descriptive statistics including means and standard deviations for the dependent variables (pre/post scores) or the test statistics t and F values and their degrees of freedom were noted.

Once all the necessary information was gathered, the best method to extract comparable statistical information from all the studies under review was decided upon. Not all the studies contained the means and standard deviations for the experimental and control groups from which one could directly compute the effect size. The studies that did not have the latter information but did have a t or F value were subjected to alternative procedures in order to convert into effect sizes.

One or more effect size(s) were calculated from the
descriptive statistics or the test statistics. The effect sizes were in turn statistically analyzed (analysis of variance), using the coded variables as independent variables and the effect sizes as the dependent variable. The details of the calculation of effect sizes and the analysis of effect sizes are discussed under the headings of calculation of effect sizes and analysis of data. Some of the studies used a pre- to post-treatment design, and examined the effect of an exercise program on a single group. The effect size could therefore only be calculated for a within group change/difference. Other studies examined the difference from pre- to post-treatment for both a treatment and a control group. This permitted the calculation of the difference between two groups in the pre- to post-change. The latter difference was called the contrast change for the purposes of calculating an effect size. Some studies provided the descriptive statistics so that the within group change could be calculated even though the study only investigated the contrast change. Studies that investigated the difference (in pre- to post-change) between an experimental group and a control group, or between two or more alternative treatments (one being exercise) for stress, were defined as contrast change studies.

Calculation of Effect Sizes

Within group change. The studies that were a pre/post design of a single treatment group and reported mean and
standard deviation scores were subjected to a modified Glassian (1977) method of calculating the effect size. Traditionally the effect size is obtained when the difference between the means of the experimental group and the control group is divided by the control group's standard deviation. Hedges (1981) proposed that a pooled estimate of the variance provides a more precise estimate of the population variance rather than the control group standard deviation, because in most cases the group variance is homogenous. Therefore, in the pre/post design the difference between the post-mean score and the pre-mean score was divided by the pooled standard deviation of the pre- and post-standard deviations. This gives the effect size of the change occurring within the experimental group only. The equation is:

\[ ES = \frac{M_1 - M_2}{S_p} \]

where the: 
- \( M_1 \) - pretest mean 
- \( M_2 \) - posttest mean 
- \( S_p \) - average standard deviation

One study with a pre/post design did not report descriptive statistics but did give the \( t \) value calculated. The following equation was used to calculate the effect size (Rosenthal & Rosnow, 1984, p. 236).

\[ ES = \frac{t}{\sqrt{df}} \]
Contrast change. The studies that had examined the differences between two groups, an exercise group and either a control group or an alternative treatment for stress, had a contrast change design. The contrast change is the difference between the experimental group’s pre- to post-means and the control group’s pre- to post-means divided by the pooled standard deviation.

The contrast change effect size was calculated as follows:

$$ES = \frac{(M_1 - M_2) - (M_3 - M_4)}{S_p}$$

where

- $M_1$ - experimental pretest mean
- $M_2$ - experimental posttest mean
- $M_3$ - control pretest mean
- $M_4$ - control posttest mean

The standard deviation is the square root of the weighted pooled variance (Thomas & French, 1986). The equation is:

$$S_p = \sqrt{\frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2}}$$

Some studies did not report the descriptive statistics but did give the test statistics. Therefore, the $t$ or $F$ value had to be used in order to estimate the effect size of the experimental group or the contrast change (Wolf, 1986, p. 35). The effect size equation for the contrast when the $t$ statistic is reported is:
The effect size equation for studies reporting the differences between groups using $F$ is:

$$ES = \frac{2t}{\sqrt{df}}$$

Although these equations were used for most of the studies included in the meta-analysis, there were two exceptions. Moses et al. (1989) transformed the tension/anxiety scores on the POMS to mean log scores. Using an anti-log table, the mean log scores of the moderate fit group and the collapsed scores of the attention-placebo and wait list groups were transformed to the mean POMS scores. This study and Dorinsky's (1984) study did not have the standard deviations of the means for the POMS scores. An estimation of the standard deviations for these studies were derived by averaging the standard deviations of other studies using the POMS measure.

**Data Analysis.** Descriptive statistics of all variables thought to influence the effect size were computed using the BMD P2D program (Dixon, 1985). Frequency tables using the BMD P4F program were computed to check for frequency counts of the values given to name the categories within each variable used (i.e., design: 1 = within group change, 2 = contrast change).
This was needed to determine if the distributions would permit grouping for analysis of variance.

Several one-way and two-way ANOVAS were computed using the BMD P2V program. One-way analysis of variance helped to decide which independent variables might be significant and have an influence in combination with another variable in shedding light on the effects of exercise on stress. Two-way ANOVAS were computed in order to assist in answering the questions posed by this study.

The independent variables were design type, stress level, type of exercise program, program length, frequency of program, leaders, attrition rate, psychological measures, composition of sample, gender, study type, and follow-up. The dependent variable was effect size.
Results

The 24 studies included in the meta-analysis provided 61 effect sizes ranging in magnitude from a minimum value of -0.14 to a maximum value of 2.02. The mean effect size over all studies was 0.57. The effect size conveys the magnitude of the difference scores and based on Cohen's (1988) categorization, it can be considered to be of "moderate" size. A test of the hypothesis that the mean effect size was different from zero was significant ($F(1, 60) = 21.17$, $p < .001$). Therefore, the result indicates that, averaged over all studies and conditions, exercise is an effective stress reducer.

Selection of Independent Variables for ANOVAS

Two-way ANOVAS were conducted to examine the effect of selected independent variables on the dependent variable anxiety. The following independent variables contained levels with sufficient cell sizes to permit a two-way analysis: design type, stress level, study type, program length, and psychological measure. One-way ANOVAS were conducted for those independent variables which, when crossed with another variable in order to perform a two-way factorial ANOVA, yielded cell sizes of less than five.

Treatment Effects

Design. A two-way (design by stress level) ANOVA was performed in order to ascertain whether there was a difference between the type of design (within group change and contrast change) and the stress level (minimally stressed and stressed
<table>
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<tr>
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<th>Effect Sizes</th>
</tr>
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</tr>
<tr>
<td>8- to 12-weeks</td>
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<tr>
<td>12 plus weeks</td>
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<tr>
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TABLE 2

The mean and standard deviation effect sizes of independent variables

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participants), and whether there was an interaction between the two variables. Analysis revealed a nonsignificant type of design main effect, $F(1,57) = .04, p<.83$, indicating that the magnitude of stress reduction within (pre- to post-) an exercise group is equal to the difference in pre- to post-change between an exercise group and a control group. This finding implies that it is the exercise per se, and not just group involvement which causes the anxiety reduction. There was no significant design by stress level interaction, $F(1,57) = 2.25, p<.14$. This effect (i.e., nonsignificant design effect) held true for both stressed and minimally stressed groups.

**Stress level.** The design by stress level ANOVA indicated a significant stress level effect, $F(1,57) = 8.09, p<.01$. Examining the means of the minimally stressed group ($M = .44$) and the stressed group ($M = .77$), it appears that exercise had more effect on stressed people's anxiety. A design by stress level ANOVA for each psychological measure level (i.e., state and trait anxiety) revealed a significant stress level effect for state anxiety, $F(1,25) = 4.92, p<.04$. It appears that stressed people reduced their state anxiety more than minimally stressed people. A nonsignificant stress level main effect for trait anxiety, $F(1,28) = 3.47 p<.07$, indicates that the stressed and minimally stressed people reduced their trait anxiety similarly. However, showing that state anxiety is significant at $p<.04$ and trait anxiety is nonsignificant at
\( p < .07, \) does not necessarily imply that there is a difference between state and trait anxiety. To test this directly, a stress level by psychological measure ANOVA was conducted. There was a nonsignificant psychological measure main effect, \( F(1, 57) = 3.37, p < .07 \) indicating that there is no difference between the reduction of state and trait anxiety. There was a nonsignificant psychological measure by stress level interaction, \( F(1, 57) = .01, p < .92. \)

Further examination of stress level included a program length by stress level ANOVA to see whether program length affected the amount of stress reduction, and if any such effect was related to initial stress level. There were nonsignificant program length and stress level main effects, \( F(2, 55) = 2.12, p < .13; F(1, 55) = 3.76, p < .06, \) but a significant stress level by program length interaction, \( F(2, 55) = 6.93, p < .01. \) Investigating the means, there is an indication that minimally stressed people reduced their stress levels the most in a 6 to 8-week exercise program (\( M = .65 \)) whereas stressed people reduced their stress levels the most in a 8 to 12-week (\( M = .92 \)) exercise program (see Figure 1).

The program length by stress level interaction was examined more closely by breaking it down to state and trait variables. To this end, ANOVAS were conducted for program length by stress level separately for state and trait anxiety. There were significant stress level by program length interactions, \( F(2, 23) = 10.33, p < .01; F(2, 26) = 5.37, p < .01, \)
Figure 1

Program Length/Weeks

Effect Size

- Minimal Stress
- Stressed
for state and trait anxiety, respectively. The nature of the interaction was quite different for state and trait anxiety.

Looking at the means, it appears that minimally stressed people reduced their state anxiety the most in the 8- to 12-week exercise program (M = .51) and the least reduction of state anxiety occurred in the 6- to 8-week (M = .27) and 12 plus week exercise programs (M = .09). However, stressed people reduced their state anxiety the most in the 12 plus week exercise program (M = 1.2) and the least in the 6- to 8-week program (M = .13). These two program conditions only had 2 effect sizes for each condition so that these findings are not robust (see Figure 2).

In examining the means of the stress level by program length interaction for trait anxiety a different pattern of anxiety reduction was seen. Minimally stressed people reduced their trait anxiety the most in the 6- to 8-week program (M = .75), leveling off at the 8- to 12-week and 12 plus week programs (M = .23). The stressed people reduced their trait anxiety the most in the 8- to 12-week program (M = 1.12) while the least effects occurred in the 6- to 8-week (M = .33) and 12-plus week exercise programs (M = .32) (see Figure 3). However, the mean of 1.12 for stressed people is inflated due to two very large effect sizes (the Setaro study using an aerobic exercise and counselling program). When these effect sizes are excluded, the mean drops to .86. The pattern of change therefore remains the same but less pronounced,
Figure 2
State Anxiety

Figure 3
Trait Anxiety
indicating that while the large effect sizes contributed to
the pattern in Figure 3, they were not the sole cause of the
pattern.

**Study type.** A design by study type ANOVA was computed.
There was a significant study type main effect, $F(1,57) =
10.65$, $p<.01$, indicating that unpublished studies have larger
effect sizes than published studies. There was a
nonsignificant design by study type interaction, $F(1,57) =
.51$, $p<.49$.

This was an unexpected finding, because unpublished
studies have a reputation of having nonsignificant findings or
methodology limitations. Consequently further analyses were
conducted in an attempt to discover if this was a spurious
finding (e.g., perhaps unpublished studies used more highly
stressed subjects).

A study type by program length, 2 by 3 factorial ANOVA
was conducted. There was a significant study type main effect,
$F(1,55) = 35.73$, $p<.01$. The means for the study type variable
showed that unpublished studies ($M = .96$) have greater effect
sizes than published studies ($M = .34$). There was a
significant program length by study type interaction, $F(2,55) =
5.13$, $p<.01$. Looking at the means, the greatest effect size
occurred in the 8 to 12-week ($M = 1.63$) unpublished study
condition (see Figure 4). However, these findings do not help
to explain why unpublished studies have larger effect sizes.

A study type by stress level, 2 by 2 factorial ANOVA was
computed. There was a significant study type main effect, $F(1, 57) = 14.23, p < .01$, and a nonsignificant study type by stress level interaction, $F(1, 57) = 3.19, p < .08$. There is however, a similar trend between the published and unpublished studies even though the effect sizes are usually bigger in the unpublished studies (see Figure 5).

**Other Variables**

Analysis of variance revealed nonsignificant main effects for frequency of program, $F(1, 59) = 1.37, p < .24$; drop-out, $F(2, 58) = .97, p < .38$; and type of leadership, $F(2, 57) = .02, p < .98$, indicating that these variables did not influence the study outcomes.

Type of exercise was a variable of interest to this study as one of the questions under investigation was which type of exercise was best suited for stress reduction. However, when a stress level by type of exercise was performed, the ANOVA could not be computed because some cell sizes were zero. A frequency table was constructed to establish the cell sizes for the stress level across type of exercise. It was found that the greatest cell size was aerobic exercise with a count of 54 of 61 effect sizes. Thus indicating that aerobic exercise was the most frequently used exercise program in examining the effect of exercise on stress. Due to insufficient data (i.e., different types of exercise prescribed for stress reduction), the question, which type of exercise is best suited for stress reduction, remains
unanswered.
Discussion

The results of this study indicate that an aerobic exercise program does reduce anxiety. The type of design (within group change and contrast change) had a nonsignificant main effect, thus indicating that exercise was a factor in reducing stress. One explanation for this finding may be that people were able to effectively use exercise as a coping strategy to reduce their emotional response to stress.

The question, is exercise more effective in treating people who report greater stress levels than people with less stress, was answered in the affirmative. Stressed people reduced their anxiety significantly more than the minimally stressed people. These findings are similar to Long (1984) and Steptoe et al. (1989) who found that participation in an exercise program reduced anxiety in stressed people.

There was a significant stress level main effect for state anxiety ($p<.04$) and a nonsignificant stress level main effect for trait anxiety ($p<.07$). Stressed people reduced their state anxiety more than minimally stressed people, whereas stressed and minimally stressed people reduced their trait anxiety similarly. However due to the small difference between state and trait anxiety it is not clear whether there is a significant difference between state and trait anxiety reduction.

Two-way ANOVAS of psychological measures by type of design and stress level revealed nonsignificant main effects.
This indicated that there was no difference in the reduction of state and trait anxiety for people participating in an aerobic exercise program. Therefore, the assumption is that there is no significant difference between state and trait anxiety. This assumption fits with Lazarus and Folkman’s (1984) model of stress because if stress/anxiety is due to a person’s perception of a situation, then both aspects of anxiety must be affected. A person could perceive certain situations as stressful or have a tendency to perceive most situations as stressful, either way, the person will be able to reassess how they evaluate a situation once they have another method of coping (i.e., exercise).

Given that the stress level has an effect on the reduction of state anxiety, one can conclude that stressed people’s perception of anxiety for particular stressful situations is considerably decreased after an exercise program. However, the tendency to perceive situations as anxiety provoking is decreased similarly for both the stressed and minimally stressed people.

It appears that both state and trait anxiety must be measured to have an accurate sense of people’s stress reduction. Identifying the specific conditions that evoke state anxiety in persons who differ in trait anxiety before an exercise program and observing whether those conditions continue to evoke anxiety after the exercise program may be worthy of further study.
There was not sufficient information regarding types of exercise programs to be able to deduce the most effective type of exercise for stress reduction. The majority of exercise programs (i.e. 89%) used aerobic exercise as an intervention for stress and 8% used a combination of aerobic exercise and an alternative treatment. These findings certainly support the notion that aerobic exercise is the most commonly prescribed exercise treatment for stress (Dorinsky, 1984; Taylor et al., 1985). It is still unclear as to whether aerobic exercise is the only form of exercise which would effectively reduce anxiety. Moses et al. (1989) and Steptoe et al. (1989) discovered that moderate aerobic exercise reduced anxiety, whereas intense aerobic exercise did not. This raises the question, what is the most effective intensity of exercise for reducing anxiety? Future studies should consider looking at the different types of exercise and their intensities as prospective stress reducing strategies.

The one-way ANOVA on program length revealed a significant program length effect. In examining the means the 8- to 12-week program had the greatest effect size and the 12 plus-week program had the smallest effect size. Thus the length of an exercise program intervention for stress might be as significant as any other type of psychological intervention length. Examination of program lengths for psychological interventions has shown that initially the participants receive considerable relief and then improvements increase
gradually as the number of sessions grow. Psychological interventions of brief to intermediate duration have better outcomes for people who are less disturbed (Garfield & Bergin, 1986).

The stress level by program length ANOVA showed a significant program by stress level interaction. Minimally stressed people decreased their stress level the most in a 6- to 8-week exercise program, whereas stressed people decreased their stress level the most in the 8- to 12-week exercise program. One possible explanation is that minimally stressed people decreased their stress in the shorter time frame as their stress was minimal and they quickly reached a ceiling effect. However, stressed people took longer to reduce their stress level and then (as seen in Figure 1) once having reached their maximum stress reduction, tapered off in the level of stress reduction. One can assume that once stressed, people would need time not only to learn a different coping strategy for stressful situations but also require time to apply the strategy in order to decrease the stress.

In order to further examine the stress reduction pattern, the stress level by program length ANOVA was also computed separately for state and trait anxiety. Both aspects of anxiety reduction were affected differently by the program length. The explanation for the difference in both aspects of anxiety reduction is not clear. The (exercise) program length however, appears to play a part in the pattern of stress
reduction. There is no literature to date concerning the importance of program length in effecting a change in participants' anxiety measures, however there is research concerning the program lengths for psychological interventions for stress (Garfield & Bergin, 1986). Researchers have arbitrarily designated a program length to fit the exercise prescription guidelines. It appears that to effectively reduce state anxiety, a 8- to 12-week exercise program for minimally stressed people and a 12 plus week exercise program for stressed people could be prescribed. In order to reduce trait anxiety the prescription would be slightly different, a 6- to 8-week exercise program is suitable for minimally stressed people and a 8- to 12-week exercise program for stressed individuals.

While it is unclear as to the reason both aspects of anxiety reduction were affected differently by the program length, results of follow-up studies may shed some light on the differing patterns of anxiety reduction. The follow-up results of Steptoe et al. (1989) and Long and Haney (1988) reported a continuation of trait anxiety reduction from pre-test to 3-month follow-up. These results refute the decrease in trait anxiety reduction after 12-weeks of an exercise program. There might be a difference in continuing an established program and participants continuing exercise at their own convenience in the follow-up period. A paucity of follow-up data concerning the effects of an exercise
intervention program on anxiety reduction does not allow for further examination. Kazdin and Wilson (1978) state that "an important, and widely recognized criterion for evaluating treatment is the durability of therapeutic change" (p. 121). This statement is upheld by the results of Long and Haney (1988) and Steptoe et al. (1989) which showed the durability of the exercise intervention.

The examination of the study type variable also offered useful information. The unpublished studies had a greater mean effect size than the published studies. When the means of the 2-levels in study type were examined across variables such as design, psychological measure, stress level and program length, it was found that the trend for both levels was the same. Since the pattern of anxiety reduction and program length was similar in both levels of study type, the argument by other researchers that Glass et al. (1981) should not include unpublished studies in a meta-analysis is unfounded. However, there is no apparent explanation for the difference in effect sizes for the published and unpublished studies.

In summary, the results demonstrated that aerobic exercise was an effective stress reducer and that stressed people decreased their anxiety more than minimally stressed people. The average effect sizes for state and trait anxiety reduction were similar, but differed considerably under different conditions of stress level and program length. Future studies probably need to measure state and trait
anxiety together when examining the effects of exercise on stress. Exercise program length probably plays a role in the most effective intervention for anxiety reduction in stress level. While unpublished studies had the greater effect size, the trends of change were similar in both the published and unpublished studies.

This meta-analysis has elucidated information regarding the effectiveness of exercise as a stress reducer and the population for which it is most effective. It has brought to light information regarding the effect of an exercise program length in anxiety reduction. While the explanation for the effect of an exercise program in anxiety reduction is unclear, future research could possibly take program length into account when prescribing an exercise intervention for stress. One of the limitations of this study was the unavailability of information from participants who dropped out of the studies included in the meta-analysis. Finally, the information that would be useful to add to our present knowledge concerning the effects of exercise on stress should be addressed.

**Recommendations**

The mechanisms that mediate the beneficial effects of exercise on cognitive processes could be extensively studied. Lazarus and Folkman's theory of stress is an excellent stepping stone to expand on research in this area. Their theory of stress focuses on the person’s perception of what is stressful and this concept could be used to ascertain the
stressful and this concept could be used to ascertain the situations which are stressful to the people participating in a research study. There would be opportunity to examine the specific situations which arouse state anxiety within people of differing trait anxiety and also to identify their coping strategies. People who are feeling stressed could be asked to identify the situations at home/work which arouse their anxiety and then groups could be subjected to varying types of exercise programs after which the participants state-trait anxiety would be retested.

There is also a need to have more specific information regarding exercise programs in order to prescribe the most effective exercise intervention for a particular population. What is the optimal type, intensity, length and frequency of exercise required to effectively reduce stress?

In order to evaluate the long-term effects of exercise as an intervention for stress, studies need to incorporate follow-up procedures in their designs.
References


Pearson, K. (1933). On a method of determining whether a sample size n supposed to have been drawn from a parent population having a known probability integral has probably been drawn at random. *Biometrika, 25*, 379-410.


Topp, R. (1989). Effects of relaxation or exercise on


**Appendix A**

**List of 24 Studies included in the Meta-Analysis**

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<th>Author</th>
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<th>Sample</th>
<th>Stress Level</th>
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Note. Psych. = psychological; Ex/Exer. = exercise; min. stress = minimal stress.