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The Effect of Chronic Exercise on Trait Anxiety in College Students

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The Effect of Chronic Exercise on Trait Anxiety in College Students

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An abstract of
A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
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Abstract

The Effect of Chronic Exercise on Trait Anxiety in College Students
By Michael T. Rothman, M.A.

The present longitudinal investigation examined the effect of a semester-long exercise program on trait anxiety in undergraduate students. A sample of 627 students participated in either a 12-13-week program of exercise (n = 402) or attended a Health Education class (n = 225) for the same length of time. Specific attention was paid to the roles of gender and initial anxiety level as potential moderators of the anxiolytic effects of exercise. Three broad categories of exercise (i.e., cardiovascular, weight-training, Eastern-philosophy-based) and nine specific types of exercise were compared with respect to their anxiolytic impact. While previous investigations of the effects of exercise on anxiety have typically relied upon Analysis of Variance (ANOVA) procedures for data analysis, the present study employed Growth Curve Analysis (GCA; Raudenbush & Bryk, 2002), to allow for an examination of both *change over time* and *rate of change* across three time points. Analyses revealed that initial anxiety level, and not gender, moderated the association between exercise participation and anxiety, such that exercisers experienced significantly lower trait anxiety at the end of the study and a significantly faster decline in trait anxiety (as compared to students in the control group), to the extent that they had higher levels of anxiety at the start of the semester. Clinically significant change was experienced by 66% of clinically anxious exercisers and 20% of clinically anxious control group participants. For exercisers, all types of exercise were equally effective in reducing trait anxiety. This investigation, while providing additional evidence for the well-documented impact of chronic exercise on trait anxiety, also provides strong evidence for the role of initial anxiety level in moderating this effect. Employing GCA procedures in the data analysis allowed for a more nuanced examination of an effect which has received significant attention in both the exercise physiology and clinical psychology literature over the past 30 years. Implications of the study findings are discussed with respect to clinical applications and future research in this field.

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Tables and Figures

THE EFFECT OF CHRONIC EXERCISE ON TRAIT ANXIETY IN COLLEGE STUDENTS

The physiological benefits of regular (i.e., chronic) physical exercise are well known (e.g., lower cholesterol, improved cardiovascular functioning, better weight maintenance, decreased risk of cancer). Although not as often cited and possibly not as widely known, exercise has also been found to have significant psychological effects. Foremost amongst these are improvements in mood more broadly, and feelings of anxiety and depression more specifically (Salmon, 2001). Although the anti-depressive effect of exercise has received more empirical attention, researchers have gathered substantial evidence for the trait-anxiolytic effect of chronic exercise. Consistent programs of exercise have been found to result in significant decreases in trait anxiety for both clinical and non-clinical populations (Landers & Petruzzello, 1994; Long & van Stavel, 1995; McDonald & Hodgdon, 1991; Petruzzello et al., 1991; Schlicht, 1994; Stich, 1998).

At this point in time, the anxiolytic effect of exercise has been well established (Buckworth & Dishman, 2006; Landers & Petruzzello, 1994). Numerous qualitative (e.g., O'Connor, Raglin & Martinsen, 2000; Raglin, 1997; Salmon, 2001) and quantitative (e.g., Landers & Petruzzello, 1994; Long & van Stavel, 1995; Petruzzello, Landers, Hatfield, Kubitz & Salazar, 1991; Schlicht, 1994; Stich, 1998) reviews have concluded that participation in a program of exercise (i.e., chronic exercise) significantly reduces both trait and state anxiety. As opposed to *state* anxiety, which refers to a more temporary experience, *trait* anxiety is a general tendency to perceive situations as potentially threatening or harmful. Researchers have documented the trait-anxiolytic effect of chronic exercise in normal (i.e., non-clinical) individuals as well as in those with

diagnosable anxiety disorders and have typically found significant anxiety reduction in both populations (Landers, 1999).

Despite the general consensus with respect to the anxiolytic properties of chronic exercise, much less agreement exists with respect to potential *moderating* influences on the chronic exercise-trait anxiety effect. For instance, some authors have found variables such as program length, exercise frequency, and exercise duration to moderate the influence of chronic exercise on trait anxiety (e.g., Landers & Petruzzello, 1994; Long & van Stavel, 1995; Petruzzello et al., 1991). Three potential moderators that have received relatively little attention, however, are initial anxiety level, gender, and exercise type. Understanding how the anxiolytic effect of exercise may differ for men versus women, for those with higher levels of anxiety, and for various types of exercise is important for designing effective exercise programs. Thus, the purpose of the present study is to examine the roles of initial anxiety level, gender, and exercise type within the context of a program of regular exercise, in order to determine whether and how these variables may affect exercise-induced anxiety reduction.

The present study addressed four primary questions:

(1) *Does initial anxiety level moderate the relationship between exercise and trait anxiety?*

(2) *Do men and women experience the same degree of anxiety reduction as a result of chronic exercise?*

(3) *Which broad type of exercise program (i.e., aerobic, non-aerobic, or Eastern-philosophy-based) results in the greatest reduction in trait anxiety?*

(4) *Which specific types of exercise are most effective for reducing trait anxiety?*

Previous reviews (e.g., Landers & Petruzzello, 1994; Long & van Stavel, 1995; Stich, 1998) comparing effect sizes generated by clinical and non-clinical populations have suggested that individuals with higher initial anxiety may benefit more from exercise than those with lower initial anxiety, but to this author's knowledge, no previous studies have examined initial anxiety as a moderator of the exercise-anxiety relationship within a single study.

The role of gender in the effect of exercise on anxiety has received relatively little attention in the exercise literature, as compared to other potential moderating influences. Most previous studies have not directly compared the degree of anxiety reduction experienced by males versus females, and the quantitative reviews attempting to shed light on this issue have described conflicting results. However, in addition to basic physiological differences between men and women, evidence from the study of anxiety suggests that women are more likely to experience anxiety (e.g., Barlow, 2004; Craske, 1999). Thus, gender could emerge as an important variable that influences the effect of exercise on anxiety.

Within the exercise and anxiety literature, examination of how type of physical activity may influence the extent of anxiety reduction has been problematic. Exercise type has typically been conceptualized as either *aerobic* or *non-aerobic*. Aerobic exercise is physical activity designed to improve the functioning of one's cardiovascular system (e.g., heart and lung capacity and efficiency) and generally includes such activities as running, walking, aerobic dance, cycling and swimming. Non-aerobic

exercise refers to physical activities that do *not* specifically focus on, nor specifically result in, enhanced cardiovascular functioning. Typically, such activities involve exercises focusing on other aspects of physical fitness, such as muscular strength, endurance, and flexibility. By far, the majority of exercise and anxiety investigations have utilized *aerobic exercise* paradigms.

One problematic aspect of the exercise and anxiety literature is the fact that different authors conceptualize non-aerobic exercise differently, such that this category often seems to serve as a 'catch-all' term for any physical activity not involving aerobic exercise. Thus, non-aerobic exercise in one study might involve weight training, while non-aerobic exercise in another study might include activities such as yoga, stretching or relaxation exercises, making it difficult to make cross-study comparisons of the effect of non-aerobic exercise on anxiety. Of most relevance to the present discussion, however, is that the few reviews attempting to compare the relative effects of aerobic vs. non-aerobic exercise on trait anxiety have, not surprisingly, yielded inconsistent findings. In the present study, non-aerobic exercise will specifically refer to weight-training activities, involving either free-weights (i.e., dumb bells or bar bells) or Nautilus-type weight machines.

Along with the more typically studied aerobic and non-aerobic exercise, the present study will also evaluate the effect of "Eastern-philosophy-based" physical activities, such as yoga, T'ai Chi and Martial Arts. The effect of Eastern-philosophy-based exercise on trait anxiety has received relatively little empirical attention in the exercise and anxiety literature, though at least several studies have found various forms of Eastern-philosophy-based exercise to be effective at reducing trait anxiety in clinical

and non-clinical populations (e.g., Javnbakht, Kenari, & Ghasemi, 2009; Michalsen, Grossman, Acil, Langhorst, Lüdtke, Esch, Stefano, & Dobos, 2005).

Not only have very few studies examined the relative effects of aerobic versus non-aerobic exercise programs on trait anxiety, almost none have compared the anxiolytic effects of *specific* types of aerobic or non-aerobic activity (e.g., swimming versus jogging). Amongst the exercise programs included in the present study are different *types* of aerobic and non-aerobic activity. This will allow a comparison of these different aerobic and non-aerobic types, in order to provide a more targeted examination of what specific types of activities lead to the largest amount of trait anxiety reduction.

Anxiety

Although related to fear, anxiety can be differentiated from fear in multiple ways. While fear typically involves a brief reaction to a specific stimulus, anxiety is a more persistent response - generally involving tension, worry, and negative anticipation - to a broader range of stimuli, which many times are not readily apparent. Anxiety is also thought to involve a significant cognitive component, often exemplified by a negatively biased appraisal of stressful stimuli and of the individual's ability to cope with them (Landers, 1999). Indeed, according to Lazarus and Cohen (1977), as cited in Landers (1999) anxiety typically arises "…in the face of *demands that tax or exceed the resources of the system or* …demands to which there are no readily available or automatic adaptive responses" (p. 109). Thus, the biased cognitive appraisals present in anxiety may often serve to perpetuate one's anxious condition (O'Connor, Raglin, & Martinsen, 2000). Like fear, anxiety can also involve a significant physiological component, typified by such responses as a quickening of one's heart rate, increased sweating, or nausea.

Trait vs. State Anxiety

According to Speilberger (1972), anxiety is an emotional response to real or perceived stressors, which consists of feelings, thoughts, or bodily changes. The experience of anxiety can range from a relatively short-term, transient condition to a more long-term and general one. Probably most well known in the conceptualization of anxiety is the distinction between *trait* and *state* anxiety (O'Connor, Raglin & Martinsen, 2000). State anxiety is defined as a very temporary condition, the experience of which may change dramatically in a short span of time. Trait anxiety is a general tendency to experience anxiety. It reflects a more general vulnerability to stress, which leads to a relatively consistent perception of situations as threatening. Thus, those with high trait anxiety are predicted to experience more frequent and intense instances of state anxiety in a given threatening situation as compared to people characterized by average or low trait anxiety (Raglin, 1997). However, it is important to note that one's experience of high state anxiety in a given situation is *not* necessarily an indication of high trait anxiety.

Despite being separate concepts, however, state and trait anxiety do share a significant degree of overlap. In the most commonly used measure of anxiety in the exercise-anxiety literature, the State Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983), the correlation between the State and Trait versions of the measure was found to range from $r = .59$ to $r = .75$ over four samples (working adults, high school students, college students, and military recruits). However, the test-retest reliability of the two anxiety distinctions tends to be quite different, as would be expected given the different nature of trait vs. state anxiety. While Spielberger

et al. (1983) report high test-retest reliability for the trait scale of the STAI (r = .70 - .77), they found a test-retest reliability estimate for state anxiety as low as .16.

Previous reviews (e.g., Landers & Petruzzello, 1994) have found chronic exercise to reduce *both* state and trait anxiety. However, due to the more temporary nature of state anxiety, in an effort to better isolate the effect of a program of exercise on more enduring characterological aspects of anxiety, the present study will focus primarily on *trait* anxiety.

Anxiety and Anxiety Disorders

In addition to the state-trait distinction, anxiety can be broadly classified as being either *clinical* or *non-clinical.* Anxiety is a normal response to real or imagined danger, and having experienced intense anxiety does not imply that one has an anxiety *disorder*. Clinical anxiety disorders involve the same basic symptoms as non-clinical anxiety (e.g., affective tension, physiological changes, negative thought patterns, and behavioral avoidance); thus, differentiation between individuals meeting and not meeting criteria for a clinical anxiety disorder is generally based on the number and intensity of symptoms and the degree of functional impairment (O'Connor, Raglin, & Martinsen (2000).

Anxiety disorders are one of the most prevalent mental health diagnoses, second only to substance abuse (O'Connor, Raglin & Martinsen, 2000). According to the National Comorbidity Survey (NCS; Kessler, McGonagle, Zhao & Nelson, 1994), approximately 17% of young to middle-aged adults experience an anxiety disorder each year. Across the lifespan, the proportion of women (31%) and men (19%) experiencing anxiety disorders is even higher (Kessler et al., 1994). The emotional and financial costs

of untreated anxiety disorders are great and some evidence indicates that only a relatively small proportion of individuals requiring treatment actually receive it (Craske, 1999).

Gender and Anxiety

Research indicates a definite gender difference with respect to anxiety (Barlow, 2004; Craske, 1999). Women are more likely than men to experience anxiety (Barlow, 2004) and be diagnosed with an anxiety disorder (Craske, 1999). Evidence for this gender bias has been found with girls as young as 6 years old (Lewinsohn, et al., 1998, as cited in Craske, 1999). Of particular relevance to the present study is the fact that this gender bias has also been shown to extend to Generalized Anxiety Disorder (GAD), which involves a tendency to experience anxiety across a variety of situations and contexts and, by its nature, is probably most similar to the concept of trait anxiety than any of the other anxiety disorders. Evidence from both the Epidemiological Catchment Area (ECA) study (Blazer, 1991) and the National Comorbidity Survey (NCS; Kessler et al., 1998) found the 12-month prevalence rate of GAD in women to be almost twice that of men, regardless of the inclusion of individuals with comorbid disorders (as cited in Howell, Brawman-Mintzer, Monnier & Yonkers, 2001).

Treatment of Anxiety

Given the high prevalence of anxiety disorders and their adverse psychological, interpersonal, and economic effects, it seems important to develop as many effective treatment methods for anxiety as possible. The most well studied and effective treatments for anxiety disorders are behavioral and cognitive behavioral psychotherapy and psychotropic medication. Cognitive behavioral therapies (CBT) for anxiety typically involve helping individuals to identify and challenge maladaptive, anxiety-producing

thought patterns and exposing them to the feared stimulus (Craske, 1999). With respect to psychotropic medications, selective serotonin reuptake inhibitors (SSRIs) and benzodiazepines have generally been found to be very effective for the reduction of anxious symptoms (Craske, 1999). The combination of psychotherapy and medication is also a widely used and highly effective treatment.

While psychotherapy and medication have been shown to be effective treatments for anxiety disorders, these treatment options have drawbacks. First, they are costly and thus not available to all members of the population. Even the briefest course of psychotherapy involves multiple sessions, the expense of which is rarely covered entirely by insurance (not to mention that many members of the population are uninsured), and medications are likewise expensive and involve the additional cost of oversight by a psychiatrist or other physician. Additional concerns with medication treatment include the fact that identifying the most effective drug and dosage for a particular individual can be a time-consuming and frustrating process, and the possibility of experiencing aversive side effects (although less common with newer drugs) also exists (Paluska & Schwenk, 2000). Given the potential liabilities of traditional anxiety treatment, identifying effective, low-cost and widely available alternative treatments for anxiety, such as chronic exercise, is very important. Moreover, current interest in the prevention of anxiety disorders has heightened the appeal of exercise as an alternative or adjunct to traditional interventions, such as psychotherapy or drug therapy (Landers, 1999).

Chronic Exercise and Trait Anxiety

To date, at least seven quantitative reviews have examined the effect of exercise on anxiety in general, as well as the effect of chronic exercise on trait anxiety, more

specifically (Landers & Petruzzello, 1994; Long & van Stavel, 1995; McDonald & Hodgdon, 1991; Petruzzello et al., 1991; Schlicht, 1994; Stich, 1998). Despite differences in scope, study inclusion criteria, and sample characteristics (i.e., clinical vs. non-clinical status of participants), these reviews have generally found chronic exercise to reduce trait anxiety significantly. While the majority of exercise and anxiety investigations have focused on *main effects*, a number of reviewers have also been able to shed significant light on potential moderating variables. An overview of the chronic exercise-trait anxiety literature is presented below, beginning with assessments of the overall effect of chronic exercise on trait anxiety (i.e., main effects), followed by a summary of the evidence for various factors thought to influence the chronic exercise-trait anxiety relationship (i.e., moderating variables).

Evidence for the Main Effect of Chronic Exercise on Trait Anxiety

Stich (1998) conducted the most recent meta-analysis of the exercise and anxiety literature. His review is the only known meta-analysis of the exercise and anxiety literature to focus exclusively on *clinical samples*. In addition, in order to address the co-morbidity of anxiety and depression, Stich's review focused exclusively on individuals with trait anxiety or depression. Participants in the studies included had a mean anxiety rating in at least the mild range (above 50th percentile) and no studies involving non-distressed participants were included. He excluded studies with medical/physical problems (including heart attack victims) and required each study to have a relevant comparison group. He limited his review to investigations of chronic exercise, as the exercise training in each study had to last at least 4 weeks. Stich's review included 21

investigations of trait anxiety (which yielded 33 effect sizes). He found the overall effect size for trait anxiety to be $d+ = +0.42$, which was very comparable to that for depression.

Long and von Stavel's (1995) meta-analysis focused solely on studies examining chronic exercise and trait anxiety in adult "high-stressed" samples. However, their review focused on "non-clinical" samples, as they excluded studies of psychiatric patients. Their review included examinations of both state and trait anxiety and only studies with exercise programs involving 20 minutes of training, 2-3 times per week, for at least 6 weeks. The 40 investigations comprising their review yielded 76 effect sizes. The authors calculated separate effect sizes for the within group studies (those studies having no control group) and the contrast group studies (i.e., those studies comparing exercise training to at least one other condition). The overall effect size for anxiety was based upon *combined* state and trait measures of anxiety. The within group studies (consisting of 26 effect sizes extracted from 15 studies) yielded an overall effect size of .45, indicative of a moderate reduction in anxiety. For the contrast group studies, 28 studies provided 50 effect sizes and yielded a small but significant average effect size of .36. Thus, whether compared to control conditions or alternative treatments, Long and von Stavel found that overall, chronic exercise resulted in a significant reduction in anxiety.

In order to address certain limitations of earlier reviews, Schlicht (1994) conducted a meta-analysis of the exercise and anxiety literature. Like Long and von Stavel (1995), he focused on the normal population and excluded clinical samples. He examined 20 exercise and anxiety studies published between 1980 and 1990, the majority of them involving some form of aerobic exercise. However, as he does not specify

whether all of the studies included in his review involved *chronic* exercise, some may have been *acute* exercise programs. He included studies measuring both state and trait anxiety and the overall effect size is a combination of these measures. The 22 effect sizes extracted in his review yielded an overall effect size of d = -.29, indicative of a significant but small reduction in anxiety as a result of exercise.

Schlicht's meta-analysis was criticized by Petruzzello (1995) for basing his findings on a relatively small subset of the exercise and anxiety literature. In addition, Schlicht's overall main effect for exercise was based upon the *combination* of effect sizes from measurements of *both state and trait anxiety*. Although exercise has been consistently found to reduce *both* forms of anxiety (Petruzzello et al., 1991), and despite the significant degree of overlap between state and trait anxiety, these two anxiety distinctions are not equivalent.

In one of the earliest quantitative reviews of this area, McDonald and Hodgdon (1991) examined the effect of exercise on anxiety. The authors do not specify, but their review appears to be a mix of clinical and non-clinical studies. Although they included both studies of state and trait anxiety in their review, they calculated separate effect sizes for each. In addition, while they don't mention "chronic" exercise specifically, their review examines "fitness training", so it appears to be focused on *chronic* exercise. The age of participants in the studies included in their review ranges from young to older/geriatric adult. With respect to exercise type, all of the programs involved *aerobic* exercise. McDonald and Hodgdon based their review upon 11 studies, from which they calculated approximately 20 effect sizes. Seventeen trait studies (20 effect sizes) yielded a significant effect size of d = -.254. Also, twenty state effect sizes led to a significant

effect size of d = -.279. Thus, the authors found a significant reduction in both trait and state anxiety for exercise training programs. However, the clinical status of the samples included in their study is not entirely clear.

Schlict (1994) later criticized McDonald and Hodgdon's review because it was limited to studies involving only *aerobic* fitness training and by the use of an "older" (p.277) meta-analytic technique; specifically, one originally devised by Smith and Glass (1977), which does not allow for an examination of effect size homogeneity.

In the most comprehensive quantitative review of the exercise and anxiety literature to date, Petruzzello, et al. (1991) conducted three separate meta-analyses, examining the effect of exercise on state, trait and physiologically based indices of anxiety, respectively. Using more liberal inclusion criteria than subsequent quantitative reviews, the authors examined 124 studies from 1960 through 1989 and extracted 62 individual chronic exercise-trait anxiety effect sizes. While their review included studies of normal, psychiatric, and high anxious individuals, they examined "health status" as a moderator variable and so were able to calculate separate effect sizes for each of these different groups. For trait anxiety, the authors found an overall effect size of d = .34. For state anxiety, they found an overall effect of d = .24, which was based upon 204 effect sizes. For physiologically based measures of anxiety, the overall effect was d = .56 and was based upon 138 effect sizes.

Landers and Petruzzello (1994) conducted a follow-up expansion of Petruzzello et al.'s review, which included a number of new empirical studies completed through 1992. As with Petruzzello et al.'s original meta-analysis, Landers and Petruzzello included all studies in their review that examined the effect of exercise on anxiety, regardless of study

quality. The overall chronic exercise-trait anxiety effect size, based upon 51 individual effect sizes *from clinical and non-clinical samples combined*, was d = -0.40, indicating a significant and moderate pre to post decrease in trait anxiety. This value was comparable to the effect size from Petruzzello et al.'s original (1991) review.

From the preceding summary, it is clear that quantitative reviews of exercise and anxiety have generally concluded that chronic exercise results in a significant decrease in trait anxiety. Although the size of the effect differs from one review to the next, overall, chronic exercise appears to result in a small to moderate anxiolytic effect. In addition, this anxiety reduction has been found in normal populations and populations of "high stressed" individuals or those with diagnosable anxiety disorders.

Moderators of the Effect of Chronic Exercise on Trait Anxiety

While the exercise and anxiety literature has primarily tended to focus on main effects, attention has been given to multiple potential moderator variables. To follow is a summary of the evidence for the possible moderating effects of the variables relevant to the present study: initial anxiety level, gender, and exercise type.

Initial Anxiety Level. Some authors have suggested that an individual's initial anxiety level is an important factor with respect to the amount of anxiety reduction he or she will experience (e.g., Landers & Petruzzello, 1994). While this variable has received relatively little attention, the extant reviews suggest that initial anxiety level does in fact moderate the effect of exercise on anxiety, such that individuals with *higher* initial anxiety should experience a *greater* reduction in anxiety following a program of exercise. For example, Landers and Petruzzello (1994) found that compared to non-clinical participants, there is a tendency for higher reductions in trait anxiety for cardiac

rehabiliation, psychiatric, and highly anxious subjects and thus concluded that there is strong evidence that clinical samples yield higher effect sizes for anxiety reduction than non-clinical samples. Similarly, Long & van Stavel (1995) found "high-stressed" samples to experience greater anxiety reduction than "non-stressed" samples. Stich's (1998) review also supports this finding. Focusing exclusively on the effects of exercise on anxiety in clinical samples, he not only found exercise to result in significant anxiety reduction, but his overall effect size ($d = 0.94$) was *significantly larger* than had previously been found with reviews focusing on either non-clinical or a combination of non-clinical and clinical samples.

Gender. Previous research with respect to physiological and emotional gender differences provides some evidence that men and women may experience exercise-induced anxiety reduction differently. For instance, Hollman and Hettinger (1990; as cited in Schlicht, 1994) found that women possess less muscle mass and have lower minimum oxygen intake than men. Also, Schwarzer (1984; as cited in Schlicht, 1994) found women to report higher anxiety scores than men and to show a greater vulnerability towards depressive moods, while men show a greater prevalence of aggression.

Although some individual studies have examined the role of gender in the effect of exercise on anxiety, the topic has not received enough attention to yield any meaningful conclusions. The lack of attention is not just due to studies being limited to only one gender, but also to authors failing to assess the effect of gender (i.e., assessing men and women separately). In addition, the quantitative reviews that have attempted to

examine gender as a moderator of the effect of exercise on anxiety have yielded inconsistent findings.

Quantitative Reviews Examining Gender. As part of their (1991) meta-analysis of the exercise and anxiety literature, in a comparison of male and female samples, McDonald and Hodgdon (1991) found a significant decrease in state and trait anxiety in *male* samples, but *not* in *female* samples. Thus, the overall decrease in trait anxiety was seen almost exclusively in *males,* and gender was a moderator of the effect of exercise on trait anxiety. The authors found only two studies in which women achieved significant decreases in anxiety, but only one of these investigations involved young adults (i.e., Maloney, Cheney, Spring & Kanusky, 1986).

Neither Schlicht (1994) nor Long and van Stavel (1995) found gender to be a significant moderator of the exercise-anxiety relationship. However, Long and van Stavel found women-only interventions to be less effective in reducing anxiety than male-only or mixed groups. It is important to note, however, that within the female-only effect sizes, six were negative and were from the same study (Griffith, 1982). With these effect sizes removed, the within-group effect was not significant.

Individual Studies Examining Gender. Relatively few individual studies have examined the role of gender as it relates to the effect of exercise on anxiety and even fewer have done so either in the context of chronic exercise programs and/or with younger adult populations, as is the focus of the present study. In an investigation involving chronic exercise, Maloney et al. (1986) examined young adult Army personnel participating in either a 5-week or a 16-week training course. Participants exercised three times per week for one hour (which included stretching, running, and a cool down) and

completed the STAI-trait measure before and after their participation in the training program. For participants in the 5-week program, men but *not* women experienced significant decreases in trait anxiety, while *both* men and women experienced significant increases in self-esteem. On the other hand, while both men and women in the 16-week program witnessed significant decreases in trait anxiety, the women's trait anxiety decrease was more highly significant. In addition, women and *not* men in the 16-week program had a significant increase in self-esteem.

In a study involving only a single bout of exercise (i.e., acute exercise), Rocheleau, Webster, Bryan and Frazier (2004) assessed state changes in state anxiety and perceived exertion in male and female college students engaged in either weight training or a cardiovascular workout. The authors found a number of gender differences. For example, their analyses revealed that gender was a reliable predictor of post-exercise mood, with women reporting lower post-exercise negative mood than men. This result was qualified by an interaction with exercise type, such that lower post-exercise mood was only found for those women engaging in a weight training, but not a cardiovascular, workout. Rocheleau et al. also found a pronounced gender difference in post-exercise exhaustion, with women reporting lower exhaustion scores than men. In addition, a significant gender by workout duration interaction indicated that for women but not men, increased workout duration was associated with lower post-exercise exhaustion scores. Finally, a gender by perceived exertion interaction emerged such that for women, the increases in exertion were associated with decreases in exhaustion, whereas the opposite was true for men (thus, when women exerted themselves *more*, they felt *less* exhausted).

Thus, examinations of both chronic and acute exercise training have found women to experience significantly greater decreases in anxiety (both state and trait) than their male counterparts. However, as these findings were the result of only two studies and depended upon interactions with variables such as the type of exercise and the length of the program, it is not possible to conclude that women generally experience a greater decrease in anxiety than men as a result of physical training.

Type of Exercise. One potentially important variable that may affect the extent of anxiety reduction associated with a particular program of exercise is the type of exercise participants are performing. Within the exercise and anxiety literature, "exercise type" has typically been conceptualized as either aerobic or anaerobic exercise. Conclusions about the relative anxiolytic properties of aerobic versus non-aerobic exercise have been difficult to make for a number of reasons. First, although a number of investigations have utilized non-aerobic exercise programs, the vast majority of exercise and anxiety studies have utilized *aerobic* exercise. Although several exercise and anxiety reviews have attempted to quantitatively compare aerobic vs. non-aerobic exercise, their conclusions have been inconsistent. In addition, the significantly smaller number of non-aerobic studies as compared to aerobic studies has made many such aerobic – non-aerobic comparisons questionable. Previous aerobic – non-aerobic comparisons are also problematic given the significant variability in specific types of non-aerobic activity from one study to the next. For example, while non-aerobic activity in one study may consist of weight training, non-aerobic activity in another study might involve dancing, yoga or stretching exercises.

Reviews Examining Type of Exercise. Several reviewers have attempted to compare the effects of aerobic and anaerobic programs, with inconsistent results. While some have found aerobic exercise to result in greater anxiety reduction than anaerobic exercise (e.g., Petruzzello et al., 1991), others have found no difference between the anxiety reduction due to aerobic vs. anaerobic programs (Schlicht, 1994; Stich, 1998). The results of one review even found anaerobic exercise to lead to *increases* in anxiety (e.g., Landers & Petruzzello, 1994). However, the aerobic vs. anaerobic comparisons in the extant reviews have been based upon so few anaerobic studies, that the results of these comparisons are highly questionable.

For example, although Petruzzello et al.'s review found a significant effect of aerobic exercise of $d = .36$ (based upon 51 effect sizes) and an anxiety-increasing (though non-significant) effect for non-aerobic exercise ($d = -.16$), their analysis was based upon only two non-aerobic effect sizes. On the other hand, Stich (1998) found a similar effect for aerobic and non-aerobic exercise ($d+ = 0.10$), but this comparison was based on only two studies. Similarly, Schlicht (1994) found no difference between aerobic and non-aerobic exercise in reducing anxiety. His analysis (involving 19 aerobic and only 3 anaerobic samples) found no evidence that exercise type moderated the effect of physical exercise on anxiety. As the results of his analysis were highly heterogeneous, he suggests performing a more detailed exercise type analysis, using "additional subgroup analyses" (p. 282).

Finally, Landers and Petruzzello (1994) found some evidence that non-aerobic exercise had the *opposite* effect of aerobic exercise (i.e., increased participants' anxiety), but their results were inconclusive. They cite two effect sizes for non-aerobic exercise,

which Petruzzello et al. report in their (1991) review, indicating an anxiety-increasing effect of chronic exercise. In addition, the authors also found some evidence for this opposite (i.e., anxiety-inducing) effect among the additional non-aerobic studies included in their review, which together yielded an average effect size of $d = .019$ and indicated a slight *increase* in anxiety.

Thus, based upon the results of several quantitative reviews, it is not entirely clear whether non-aerobic exercise programs result in a similar or lesser degree of anxiety reduction than aerobic exercise, or whether non-aerobic exercise may sometimes serve to *increase* anxiety. In addition, not only did all of the authors of the above meta-analyses conduct very broad comparisons of aerobic vs. non-aerobic exercise, but in almost every case, this comparison was based on a sample where the number of aerobic studies far outweighed the number of non-aerobic studies. As a result, the few findings that do emerge from these meta-analyses are not very conclusive.

In contrast to the above reviews, McDonald and Hodgdon conducted an analysis comparing more specific forms of aerobic and "mixed" (i.e., aerobic and non-aerobic) training. The majority of the aerobic studies involved running/jogging/walking programs or cycling programs, while the "mixed" program involved a combination of weight training and an aerobic activity. They found no evidence that any one form of aerobic exercise produced any greater effect on trait anxiety than any other form. Unfortunately, the authors do not provide the effect sizes for these individual group types and do not report how many effect sizes they included in the largest group (i.e., run/jog/walk). In addition, their analysis was fairly crude, as the exercise type groupings that the authors used were still based upon combinations of fairly dissimilar activities. For example, they

compared studies using a combination of running, jogging, and walking programs to those using a combination of biking, jogging, and walking training. Thus, although their analysis provides a slightly more targeted examination of exercise type than in previous reviews, their review still lacks the desired level of specificity required to begin drawing firm conclusions about how one specific type of physical activity tends to affect trait anxiety.

Relative to aerobic and non-aerobic forms of exercise, Eastern-philosophy-based exercise programs have received far less attention in the exercise and anxiety literature. The following is a brief review of the impact of yoga on anxiety in clinical and non-clinical populations.

Javnbahkt et al. (2009) examined the effect of yoga on anxiety in a non-clinical sample. Trait anxiety was assessed in a sample of 65 women before and after participation in either a two-month-long yoga program (n = 34) or a wait-list comparison group (n = 31). While women in the control group experienced no change in anxiety, the trait anxiety of yoga participants significantly decreased pre to post. In another study consisting of an all-female sample, Michalsen, et al. (2005) examined changes in trait anxiety in "emotionally-distressed" women who participated in either an Iyengar yoga (n = 16) or wait-list control (n = 8) condition for a period of three months. Yoga participants' trait anxiety scores significantly decreased from pre to post, but wait-list control participants' anxiety scores did not change.

In a cross-sectional study, Bond, Lyle, Tappe, Seehafer, and D'Zurilla (2002) compared the trait anxiety of students and adults who had participated in either a six-month program of moderate exercise (n = 86), T'ai Chi (n = 71) or who had been

sedentary (n = 94) for the same duration. Overall, the moderate exercisers and T'ai Chi participants had significantly lower trait anxiety than the sedentary group, though the authors found that this effect was moderated by age and gender. Younger men participating in moderate exercise and T'ai Chi had significantly lower trait anxiety scores than their sedentary counterparts. For women, older participants participating in T'ai Chi classes witnessed lower trait anxiety scores than either the sedentary or moderate exercise group.

Kirkwood, Rampes, Tuffrey, Richardson, and Pilkington (2005) reviewed the evidence for various forms of yoga as a treatment for anxiety and anxiety disorders in eight studies involving participants either diagnosed with anxiety disorders or whom (based upon the participants' scores on measures of anxiety) the respective study authors considered to have significant levels of anxiety. Despite some positive findings for the treatment of various anxiety disorders, the authors noted significant methodological limitations of the studies reviewed and concluded that it was "not possible to say that yoga is effective in treating anxiety or anxiety disorders in general" (p. 889). In a broader review including 20 randomized controlled trials examining the effect of Eastern-philosophy-based practices on mental health, Arias, Steinberg, Banga, and Trestman (2006) examined the evidence for meditative practices in general (including yoga) as a treatment for anxiety in psychiatric populations. Though the authors found some evidence that yoga and meditation were effective in treating anxiety, it was limited to only two studies included in their general review.

Etiology of Anxiety and Proposed Mechanisms for the Anxiolytic Effects of Exercise

Based on various etiological theories of anxiety disorders, exercise researchers have proposed a number of different explanations (mechanisms) for the anxiolytic effects of exercise. Before reviewing the explanations for how exercise reduces anxiety, theories for the etiology of anxiety are briefly considered.

Etiology of Anxiety and Anxiety Disorders

To date, a number of attempts have been made to explain the etiology of anxiety and anxiety disorders (e.g., genetic, cognitive, neurobiological). Genetic theories of anxiety development have received a sizeable amount of attention in the anxiety literature. Studies examining a genetic-based etiology of anxiety suggest a moderate genetic component (e.g., accounting for as much as 30-40% of the variance in the case of panic disorder) (Buckworth & Dishman, 2006; Paluska & Schwenck, 2000).

Cognitive theories of anxiety emphasize selective biases in the cognitive processing of anxious individuals to explain the development and maintenance of anxiety. Such biases might occur in one's appraisals, attention and memory. For example, negatively biased cognitive appraisals may include the overestimation of the degree of threat a particular stimulus poses (which may be based on the misinterpretation of benign physiological symptoms) or the underestimation of one's ability to handle stressful circumstances. On the other hand, the biased attention and memory of anxious individuals leads them to more selectively attend to and have better recall for potentially anxiety-producing information (O'Connor, Raglin & Martinsen, 2000; Paluska & Schwenck, 2000).

An alternative explanation for the genetic and cognitive theories of anxiety lies in the neurobiology of anxious individuals. Although the involvement of multiple brain structures is doubtless, the amygdala appears to play a crucial role in the anxiety process (LeDoux, 1998). Located in the temporal lobes and known to be intimately involved with emotion, the amygdala's importance in the anxiety process may stem from its connection to higher-level brain areas known to be involved with the integration of perceptual information (e.g., the thalamus and locus coeruleus). Thus, it is believed that the amygdala's role in anxiety may stem from its role in the assessment of perceptual information. Goddard & Charney (1997) concluded, "from an anatominical perspective, the amygdala appears to be a central structure for coordinating the cognitive, affective, neuroendocrine, cardiovascular, respiratory, and musculoskeletal components of fear and anxiety responses" (p.5).

Proposed Mechanisms for the Anxiolytic Effects of Exercise

Similar to theories explaining the genesis of anxiety and anxiety disorders, explanations of the anxiolytic effect of exercise are divided into *physiological mechanisms* and *psychological mechanisms*. Despite the existence of numerous investigations over the years geared toward further elucidating exactly how exercise exerts its influence on affect, this question remains very much unanswered (Petruzzello & Motl, 2006).

Physiological Mechanisms.

The Endorphin Hypothesis. Arguably the most popular explanation for the emotional effects of exercise is the endorphin hypothesis (Petruzzello & Motl, 2006). Along with their fellow peptides, enkaphalins and dynorphins, the endorphins are a class

of endogenous opioids that operate in the body as natural pain relievers. Beta-endorphin, which is known to have a significant impact on blood pressure and body temperature regulation and the perception of pain, is considered to be the most powerful of the endorphins (Stich, 1999). When the body experiences periods of physical stress (such as exercise), the anterior hypothalamus secretes beta-endorphin into the bloodstream. The endorphin hypothesis proposes that it is this release of beta-endorphin that results in the anxiolytic and anti-depressive effects of exercise.

The Monoamine Hypothesis. The Monoamine Hypothesis, which includes both the Serotonin Hypothesis (Chaouloff, 1997) and the Norepinephrine Hypothesis (Dishman, 1997), attributes the exercise-induced reduction in anxiety and depression to changes in brain monoamine neurotransmitters (e.g., serotonin, norepinephrine, and dopamine). This hypothesis stems from the observation that mood and anxiety disorders are not only associated with reduced aminergic levels in the brain, but that medications (such as serotonin selective reuptake inhibitors (SSRIs)) designed to reverse such aminergic depletion often result in a reduction of mood and anxiety-related symptoms (Stich, 1999). The major drawback of the monoamine hypothesis is the difficulty of measuring such brain chemicals in humans. As a result, while the role of the monoamines in anxious and depressive symptoms has received extensive study in animals, the role of aminergic neurotransmitters in human anxiety and depressive disorders remains unclear (Petruzzello & Motl, 2006).

The Thermogenic Hypothesis. The thermogenic hypothesis (Morgan & O'Connor, 1988) attributes the anxiolytic effect of exercise to the increase in body temperature experienced as a result of exercising. The brain senses the rise in body

temperature and initiates muscular relaxation. Through a feedback loop, this relaxation is detected by the brain and interpreted as a reduction in anxiety (or depression). According to Petruzzello & Motl (2006), of all the explanations for the emotional effects of exercise, the thermogenic model has received the greatest amount of empirical attention. The major conclusion of work on this model is that the affective benefits of exercise are likely *not* due to a rise in body temperature. Although some have proposed that increases in *brain,* and not *body,* temperature may actually account for these effects, measuring such exercise-induced brain temperature changes has yet to be satisfactorily accomplished (Petruzzello & Motl, 2006).

Psychological Mechansisms.

The Mastery/Self-Efficacy Hypothesis. The Mastery Hypothesis maintains that exercise exerts its effects on anxiety and depression through the sense of accomplishment or apparent increase in self-efficacy experienced after engaging in exercise. This rise in self-efficacy is thought to result in a renewed sense of control over or ability to cope with one's environment (Petruzzello & Motl, 2006). Support for the mastery hypothesis comes from investigations designed to directly manipulate participants' self-efficacy and its emotional impact (e.g., McAuley, Talbot & Martinez, 1999). McAuley et al. (1999) were able to influence participants' affective exercise response by providing participants who had just completed an exercise test with either incorrectly positive (high-efficacy group) or negative (low-efficacy group) feedback concerning their level of fitness. Although this study obviously involved *acute* exercise and *state* anxiety, participants receiving high efficacy feedback reported experiencing significantly greater anxiety reductions than the low-efficacy group.

The Distraction Hypothesis. Another proposed psychological explanation that has received much attention is the distraction hypothesis (Bahrke & Morgan, 1978). The distraction hypothesis suggests that the time out, or break, from one's stress (or from *thoughts about one's stress*) afforded by engaging in exercise leads to a reduction in anxiety or depression. Breus & O'Conoor (1998) found evidence for the distraction hypothesis in a study involving stationary cycling in undergraduate females. Participants were assigned to one of four conditions: 20 minutes of cycling + 20 minutes of quiet recovery on the bike, 40 minutes of studying while seated on the bike, 20 minutes of exercise + 20 minutes of bike studying, or 40 minutes of quiet studying off the bike. The authors found that a significant reduction in anxiety was limited solely to the exercise-only condition. Despite the existence of some empirical support for the distraction hypothesis, researchers within the exercise and anxiety literature do not believe that a simple respite from stress or stress-related cognitions *alone* can account for affective changes following exercise (Petruzzello & Motl, 2006).

The Present Study

The present study examined the effect of a chronic exercise program on trait anxiety in a sample of 627 undergraduate students. Students participating in physical education classes involving different aerobic, non-aerobic, and Eastern-philosophy-based exercise over the course of a semester were recruited for the experimental conditions of the study. Students participating in purely didactic health education classes were recruited to serve as the control group. Students in all study conditions completed a battery of self-report measures at three assessments points: approximately 2-3 weeks after starting the exercise program, approximately 7-8 weeks into the program, and at the end of the

program, 12-13 weeks after starting exercise (i.e., "post"). The primary variable assessed at each time point was trait anxiety. In order to assess whether physical exercise may simply be acting on a more general negative affect factor, participants also completed a measure of negative affect. The study addressed the following hypotheses:

Hypothesis 1: Participation in a semester-long program of physical exercise (i.e., group membership) will predict trait anxiety, such that students in the exercise group will experience (a) lower levels of trait anxiety at the end of the study (i.e., Time 3) and (b) a faster rate of linear decline in trait anxiety over time than control participants.

Hypothesis 1a: Participants' initial levels of anxiety will moderate the association between group membership and level of trait anxiety at Time 3 and rate of change in trait anxiety over time, such that participants with higher levels of initial anxiety will experience (a) lower levels of trait anxiety at Time 3 and (b) a faster rate of decline in trait anxiety over the course of the study (i.e., greater benefits from an exercise program) than participants with lower initial anxiety.

Hypothesis 1b: Gender will moderate the association between group membership and anxiety, such that women will experience (a) lower levels of trait anxiety at Time 3 and (b) a faster rate of decline in trait anxiety over the course of the study (i.e., greater benefits from an exercise program relative to control participants).

Research has shown that women are more likely than men to experience anxiety (Barlow, 2004) and be diagnosed with an anxiety disorder (Craske, 1999). Reviews of the exercise-anxiety literature have found initial anxiety level to moderate the effect of exercise on anxiety, such that individuals with *higher* initial anxiety experience a *greater* reduction in anxiety following a program of exercise (e.g., Landers & Petruzzello, 1994;

Long & van Stavel, 1995; Stich, 1998). From this, we might expect that women, on average, would experience more significant exercise-related declines in anxiety than would men. However, very few previous studies have directly compared the effect of exercise on anxiety in men versus women. Even fewer have done so in the context of chronic exercise programs and/or with younger adult populations.

With respect to an examination of exercise type, no predictions were made in relation to decreases in trait anxiety for aerobic versus non-aerobic versus Eastern-philosophy-based programs of exercise in general, nor for comparisons of specific types of physical activity within each exercise category. As reviewed above, the results of quantitative reviews comparing the relative anxiolytic effects of aerobic versus non-aerobic exercise programs have been mixed. While some have only found aerobic exercise to result in significant trait anxiety reduction (e.g., Petruzzello et al, 1991), others have found no difference between the anxiolytic properties of these two forms of exercise (e.g., Schlicht, 1994 and Stich, 1998). In addition, the exercise literature has yet to address the more targeted question of which *specific* types of aerobic and non-aerobic exercise are most effective in the reduction of trait anxiety. As a result, no firm conclusion exists as to which activities, whether broadly (i.e. aerobic or non-aerobic) or narrowly defined (e.g., running, walking or weight-training) are most effective for reducing anxiety.

Method

Overview

The present investigation is a treatment-outcome study with a longitudinal design, consisting of pre-test, mid-point, and post-test assessments. The study included an

exercise group (i.e., students enrolled in fitness-related physical education classes) and a control group (i.e., students only enrolled in a health education class). The small subset of participants (n = 3) enrolled in both a fitness-related PE class and PE 101 Health during the course of the study were assigned to the exercise group for analysis. The data for this study were collected at Emory University, a mid-sized private university in Atlanta, GA. Data collection procedures were approved by Emory's Human Subjects Institutional Review Board.

Participants

Participants for the present study were 694 students, aged 18-24 years, recruited from the undergraduate population at Emory University. Of this initial sample, data from 627 students, including 406 females (64.8%) and 221 males (35.2%), with a mean age of 19.52 years (*SD* = 1.34) were used in the final analyses. The 67 participants whose data were not used in the analyses were excluded for the following reasons: a) age greater than 24 (*n* = 3), b) no Time 1 data provided (*n* = 14), c) enrolled in more than one physical education class (*n* = 46), d) outliers (*n* = 4).

Procedure

Sample Selection

Participants in the exercise group (*n* = 402) were recruited from exercise-based physical education classes held at the Woodruff Physical Education Center (WoodPEC), located on the campus of the university. The principal investigator was granted permission by the physical education department to come to all PE classes that were offered in the Fall semester of 2009 during the first week of class and to recruit interested students for the study. Students in fitness classes were offered five extra credit points *or*

the removal of a class absence (their choice) for completing all three time points of the study. The principal investigator contacted interested students via e-mail with a link to an online consent form (see Appendix A) and study questionnaires. Once accessing the link, participants provided their consent to participate in the study and completed a small battery of questionnaires including a demographic questionnaire, a brief assessment of the students' motivation for taking their respective fitness classes, and the measures comprising the initial study assessment (i.e., measures of trait anxiety and negative affect).

Exercising participants were recruited from the following physical education classes: Aerobic Conditioning, Aerobic Resistance Training, Basic Tai Chi, Martial Arts, Beginning Yoga, Fitness Yoga, Introduction to Racquet Sports, Beginning Racquetball, Cardio Tennis, Swimming, Indoor Cycling, Fitness Walking, Jogging, Weight Training, Resistance Training, and Stress Reduction and Flexibility.

For the analysis of exercise type, the fitness courses were divided into several basic categories: cardio, strength training, Eastern, and skills-based classes. The "cardio" category included all classes in which the exercise involved was primarily cardiovascular in nature (i.e., Indoor Cycling, Fitness Walking, Jogging, Swimming, Cardio Tennis, Aerobic Conditioning, and Aerobic Resistance Training). Strength training courses (i.e., Weight Training, Resistance Training) involved the use of free weights and weight machines (e.g., Cybex) with an emphasis on building muscular strength. Classes in the "Eastern" category included those based on traditional Eastern-philosophy-based forms of exercise (i.e., Yoga, Martial Arts, and Basic Tai Chi). Finally, "skills-based" classes

(i.e., Introduction to Racquet Sports and Beginning Racquetball) primarily emphasized learning sport-specific skills and rules.

The non-exercising (i.e., control) participants were recruited from a large undergraduate health education class involving purely didactic activities and no required exercise. Students were offered five extra credit points toward their final course grades for completing all three time points of the study. Interested students provided their names and e-mail addresses on a sign-up sheet and were later contacted by the principal investigator and given a link to the online consent form and questionnaires.

As students self-selected into the respective treatment- and control-group classes prior to the beginning of the investigation, random assignment to treatment or control conditions was not possible. While the initial physical activity level of participating students ranged from "sedentary" to "active", all participating students were medically healthy, in that they were free from physical conditions that would contraindicate a program of consistent rigorous exercise.

Data Collection

After registering for the study in their physical education or health classes, all participants were e-mailed a link to Survey Monkey (http://www.surveymonkey.com), an online data collection website, where they were able to read the consent form and electronically indicate their consent to participate in the study, as well as complete a battery of online questionnaires, including a demographic questionnaire and the measures comprising the initial study assessment (i.e., measures of anxiety, negative affect, level of physical exercise and exercise expectancy (exercise participants only)).

The Time 1 assessment was e-mailed to exercise group participants on September 20, 2009, the start of the 5th week of the semester, which represented the second or third week of exercise, depending on the class, and it was completed by 402 participants between 9/20/09 and 9/28/09 with an average number of days to completion of $M = 3.96$ ($SD = 2.54$). The Time 1 assessment was e-mailed to control group participants on September 27, 2009 and was completed by 225 students by September 30, 2009 ($M = 1.82$, $SD = 1.28$ days to completion).

Five weeks after the initial assessment (October 25, 2009), at the start of the 10th week of the semester, participants in both groups were e-mailed a link to the Time 2 questionnaires, which included all measures in the Time 1 assessment except the demographic and expectancy questionnaires. Students in both groups completed these measures by November 2, 2009 in an average of 2.42 days ($SD = 2.12$) for the exercise group ($n = 365$) and 2.94 days ($SD = 2.01$) for the control group ($n = 207$).

The links for the Time 3 assessment, which included an identical set of measures as Time 1 except for the demographic questionnaire, were e-mailed to participants in both groups at the start of the 15th week of the semester (November 29, 2009), the final week of class, and were completed by members of the exercise group ($n = 402$) in an average of 2.21 days ($SD = 2.37$) and by the control group participants ($n = 225$) in an average of 2.20 days ($SD = 1.79$).

Exercise Program

Although the specific activities in the various physical education classes differed, the programs were similar with respect to the length of the exercise program (i.e., program duration), how often students exercised as part of the class (i.e., frequency), and

the length of individual exercise sessions (i.e., exercise bout length). Each program lasted for one semester (i.e., approximately 16 weeks, with physical exercise occurring for 13-14 of these weeks). In each class, participants trained together as a group at least once per week for approximately one hour for Tuesday/Thursday classes and two to three times per week for approximately 30 minutes for Monday/Wednesday/Friday classes. The training in each class included brief warm-up and cool-down periods and participation in the primary fitness activity. The intensity of each physical fitness class, however, was largely individually determined. Although students were expected to take their training time seriously and to train in such a way as to make significant cardiovascular and/or muscular fitness gains over the course of the semester, the specific intensity level at which students trained varied from one student to another. In all fitness classes, students were permitted two absences before the activity portion of their course grade was affected.

Confidentiality

To maintain confidentiality, all participants were assigned an ID number that was paired with their data in lieu of their names. Only the principal investigator had access to all participant data. When participants gave their consent on the online consent forms, they did so without having to sign or write their names, which kept their names from being associated with their online study data. All participant data was downloaded from the internet survey website into computer statistical software (i.e., Microsoft Excel 2007, PASW Statistics 18, and HLM 6.0). Only the principal investigator and other trained research personnel had access to the database.

Measures

Demographic Information and Physical Activity Level

All participants completed a brief questionnaire on which they indicated basic background data (e.g., name, age, sex, ethnicity). They also provided information with respect to their current level of physical activity.

Exercise Expectancy

A measure of exercise expectancy (see Appendix B) was completed only by the participants in the exercise condition. At Time 1, in order to obscure the true focus of the study, exercise participants were asked to answer 10 questions regarding their expectations with respect to their participation in the physical fitness class. Students indicated their reasons for taking their respective physical fitness class and rated the extent to which they expected to benefit from participation in the physical fitness class with respect to the following areas: cardiovascular functioning, stress, muscular strength, feelings about themselves, mood, muscular development, affect and physical appearance.

Trait Anxiety

The State-Trait Anxiety Index (STAI; Spielberger, C.D., Gorsuch, R.L., Lushene, R.E., Vagg, P.R., & Jacobs, G.A., 1983) was used to assess participants' state and trait anxiety at all three study time points. The STAI includes separate subscales for state and trait anxiety, each consisting of 20 items, for a total of 40 items. Items on both subscales are answered on a 4-point scale. Responses on the state scale range from 1 ("Not at All") to 4 ("Very Much So"), while those on the trait scale range from 1 ("Almost Never") to 4 ("Almost Always"). Scores range from 20 to 80 on each subscale and from 40 to 160 for the total score, with higher scores indicating more anxiety. Both scales are composed of

the same items, except that the state anxiety scale asks respondents to answer based upon how they are feeling "right now" and the trait anxiety scale asks respondents to answer based upon how they "generally feel." Given the item similarity, the two subscales share a significant degree of overlap. For college students, the correlation between state and trait scales ranges from .59 for females to .65 for males (Spielberger et al., 1983).

The STAI has been shown to have strong psychometric properties. With respect to internal consistency reliability, alpha coefficients for male and female college students on both the s- and t-scales range from .90 to .93. Studies have found three-and-a-half-month test-retest reliability for the state and trait scales to be $r = .75$ and $r = .33$, respectively. With respect to validity, the STAI trait scale shows strong convergence with other measures of trait anxiety, such as the Taylor Manifest Anxiety Scale (TMAS; Taylor, 1953), $r = .80$ and the IPAT anxiety scale (IPAT; Cattell & Scheier, 1963), $r = .75$. In addition, the divergence data show no correlation between either scale of the STAI and measures of aptitude and achievement. For males: H.S. GPA and STAI-state: $r = -.02$, H.S. GPA and STAI-trait: $r = -.06$. For females, H.S. GPA and STAI-state: $r = -.02$, H.S. GPA and STAI-trait: $r = .00$ (Speilberger et al, 1983).

The STAI is scored by summing subjects' responses on both subscales to yield a state, trait, and overall score. The following items are reverse-scored: 1, 2, 5, 8, 10, 11, 15, 16, 19, 20 (state) and 21, 23, 26, 27, 30, 33, 34, 36, 39 (trait).

Negative Affect

The Positive and Negative Affect Schedule (PANAS; Watson, Clark & Tellegen, 1988) is a 20-item measure designed to separately assess positive and negative affect. Each scale consists of 10 adjectives 'that the respondent rates on a scale from 1 (i.e.,

"very slightly or not at all") to 5 (i.e., "extremely"), in order to indicate how well the words describe how they are feeling. The PANAS can be used with several different time instructions, from "Moment" (i.e., referring to how the respondent is feeling right now) to "General" (i.e., referring to how the respondent generally feels). The "General" time instructions will be used for the present investigation (Antony, Orsillo & Roemer, 2001). The PANAS is scored by summing the ratings for each scale.

The PANAS has demonstrated strong evidence of reliability. Internal consistency alpha coefficients (using each of the different time instructions) range from .88 to .90 for positive affect and from .84 to .87 for negative affect. Temporal stability estimates are also strong, with test-retest reliability ranging from .47 (moment) to .68 (general) for positive affect and .39 (moment) to .71 (general) for negative affect (Antony, Orsillo & Roemer, 2001).

With respect to validity, both PANAS scales have been found to correlate significantly with other relevant self-report measures. For instance, Watson, Clark & Tellegen (1988) found the State Anxiety subscale of the STAI to correlate (r = .51) with negative affect and r = -.35 with positive affect. In the same study, they found the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock & Erbaugh, 1961) to correlate (r = .56) with negative affect scores and (r = .35) with positive affect scores. Discriminative and predictive validity evidence comes from studies conducted with clinical samples, in which depressed patients obtained significantly lower positive affect scores than anxious individuals, while scoring similarly to them on the negative affect scale (Waikar & Craske, 1997, as cited in Antony, Orsillo & Roemer, 2001). In addition, negative affect scores were significantly associated with symptoms of anxiety and

depression, while positive affect scores were negatively related to depressive symptoms several years later (Watson & Walker, 1996, as cited in Antony, Orsillo & Roemer, 2001). In the present study, participants completed only the Negative Affect Scale.

Analytic Procedures

Data Analyses and Statistical Modeling

Growth curve analytic procedures (GCA; Raudenbush & Bryk, 2002) and the HLM 6 computer program (Raudenbush, Bryk & Congdon, 2004) were used to create a growth model of change in trait anxiety over the course of the study (i.e., 3 time points over 1 semester). Growth Curve Modeling (GCM) allows for a simultaneous, two-stage process in data analysis. The first stage (Level 1) is a within-person model of growth. In this study, the individual-level model estimates a trajectory of change (growth curve) for each participant's anxiety level. A simple linear model for individual growth is described by two parameters: an intercept, which captures the status of an individual at a particular point in time, and a slope (a rate of change over time). In these analyses, the intercept represents anxiety level at the end of the semester (Time 3); time was measured as days since the completion of the last set of questionnaires (at Time 3), in order to model the intercept as the end of the exercise program.

At Level 1, HLM provides tests of whether, on average, these intercepts and slopes differ significantly from zero, and whether there is variability in these estimates across participants. Though to date, no studies have examined the relationship between anxiety and chronic exercise using GCA techniques, previous longitudinal research on change in trait anxiety levels following a program of chronic exercise has consistently

demonstrated that trait anxiety decreases over time (e.g., Petruzello, et al., 1991). Therefore, linear trajectories were estimated with the data points in the present study.

Missing data at the item level represented 0.4% of the data and were accounted for using the proportion estimation procedure. Online software (Preacher, Curran & Bauer, 2003) was used to conduct post-hoc analyses for all significant moderation effects. In this procedure, simple effects were computed (a) at each level of dichotomous moderators (e.g., gender, group), and (b) at 1 SD above and below the mean, two standard deviations below the mean and at the mean for continuous moderators (e.g., initial anxiety).

Results

Descriptive Statistics

Participants were 627 undergraduate students (406 women, 221 men) with an average age of 19.52 years (*SD* =1.34) at Time 1. Regarding ethnicity, 42 students self-identified as African American/Black (6.7%), 1 as American Indian/Alaskan Native (0.2%), 217 as Asian American/Asian (34.6%), 304 as European-American/White/ Caucasian (48.5%), 18 as Hispanic/Latino(a) (2.9%), 1 as Native Hawaiian/Pacific Islander (0.2%), 12 as Middle Eastern (1.9%), 15 as Multiracial (2.4%), and 17 as Other (2.7%).

The exercise group consisted of 267 (66.4%) females and 135 (33.6%) males, and the control group consisted of 139 females (61.8%) and 86 males (38.2%). Sixty-nine (17.2%) members of the exercise group and 58 (25.8%) members of the control group reported being on a school-based varsity or intramural athletic team. In the control group, 10 participants (4.4%) reported taking psychiatric medications for anxiety or

depression during the course of the study, while 199 (88.4%) denied doing so. Twenty-eight (7.0%) exercisers reported taking psychiatric medications, while 344 (85.6%) did not. Data was not provided for this question by 16 members of the control group (7.1%), or by 30 members of the exercise group (7.5%). Ten individuals in the control group (4.4%) and 25 (6.2%) exercisers reported participating in individual or group counseling or therapy during the course of the semester, while 201 (89.3%) control participants and 347 exercisers (86.3%) did not. Data for this question was not provided by 14 members of the control group (6.2%) or by 30 members of the exercise group (7.5%).

As of Time 3, 140 (66.4%) control group participants and 215 (53.5%) exercise participants reported participating in a personal exercise routine (outside of the study-related physical education class), while 71 (31.6%) of the control group and 159 (39.6%) of the exercise group did not. No data was provided for this question by 14 (6.2%) of control group participants and 28 (7.0%) of exercisers. Exercisers who reported participating in a personal exercise routine reported doing so with the following frequencies as of Time 3: “Daily” (3.6%), “5-6 days per week” (16.1%), “3-4 days per week” (38.1%), and “1-2 days per week” (42.2%). For control participants, the frequencies were as follows: “Daily” (3.5%), “5-6 days per week” (15.3%), “3-4 days per week” (41.0%), and “1-2 days per week” (40.3%). For those engaged in a personal exercise routine, the average duration of each bout of exercise was as follows: “3 or more hours” (0.5% of exercisers and 1.4% of controls), “2-3 hours” (4.7% of exercisers and 10.0% of controls), “1-2 hours” (20.5% of exercisers and 28.6% of controls), “about an hour” (38.1% of exercisers and 30.8% of controls), “30-45 minutes” (32.1% of exercisers

and 23.6% of controls), and "less than 30 minutes" (4.2% of exercisers and 5.7% of controls).

Bivariate Relationships Between Variables Used in the Analyses

Table 1 presents the Pearson correlation matrix between the STAI-T and PANAS scores for the full sample at all time points. Tables 2 and 3 display the STAI-T and PANAS correlations for the exercise and control groups, respectively, while Spearman correlations between the independent variables, moderators, controls, and dependent variables used in the analyses are displayed in Table 4. Correlations ranged from unrelated to large in size (*rs* = .004 for T1 STAI and participation in a personal exercise routine to .460 for psychotherapy and psychiatric medication). Given that most of the correlations are relatively low, it is unlikely that there would be significant associations between predictors and the *overall levels* of the outcome variables; however, because growth curve analysis estimates trajectories of change over time, it is possible that there could be a significant association between predictors and *changes* in outcome variables over time. However, as none of the correlations were .70 or greater, suggesting an absence of multicollinearity among the variables, it was deemed appropriate to examine the variables as separate constructs.

Preliminary Analyses

Trajectories of Anxiety over the Semester

Prior research has demonstrated that trait anxiety decreases over time with chronic exercise. Based on this finding, a linear model of change in anxiety was tested from the three longitudinal data points in the present study:

$$Y_{ij}\,(\text{trait anxiety}) = \beta_{0j} + \beta_{1j}\,(\text{Time}) + r_{ij}$$

where Y_{ij} is the level of anxiety for individual *j* at Time *i,* β_{0j} is the intercept for subject *j* at Time 0 (defined as the level of trait anxiety reported at the end of the semester), β_{1j} is the rate of linear change in anxiety for individual *j* across the three time points (i.e., slope), and r_{ij} is the residual variance in repeated measures for individual *j,* which is assumed to be independent and normally distributed. The linear model was then compared to a mean-and-variance model (in which trait anxiety is modeled as fluctuating randomly around an individual's mean):

$$Y_{ij}\,(\text{trait anxiety}) = \beta_{0j} + r_{ij}$$

The linear model provided a better fit for the data, $\chi^2(2) = 24.46$, $p<.001$; thus, a linear baseline model of anxiety was specified for all subsequent analyses. This baseline model indicated that, on average, anxiety decreased over the semester across the exercise and control groups, $t(626) = -2.12$, $p<.05$. Further, there was significant between-subject variability for the linear parameter, $\chi^2(587) = 1223.00$, $p<.001$, suggesting that anxiety changed at differing rates across the sample (e.g., it may have increased or stayed relatively stable for some and decreased for others). Finally, significant between-subject variability change in anxiety over time, $\chi^2(587) = 733.64$, $p<.001$, suggested that it is appropriate to examine predictors of linear change in anxiety in the present study.

Analyses

Aim 1: Group Membership, Gender and Initial Anxiety Level

Hypothesis 1: Participation in a semester-long program of physical exercise (i.e., group membership) will predict trait anxiety, such that students in the exercise group will experience (a) lower levels of trait anxiety at the end of the study (i.e., Time 3) and (b) a faster rate of linear decline in trait anxiety over time than control participants.

The following equation was specified to examine exercise program participation as a predictor of (a) β_{0j}: level of trait anxiety at the end of the study (i.e., Time 3) and (b) β_{1j}: changes in trait anxiety over time. Group membership and gender (dichotomous variables) were entered as uncentered at Level 2 as predictors of both of these parameters. Initial anxiety (i.e., Time 1 trait anxiety score), a continuous variable, was entered as grand-mean centered for both the time 3 anxiety parameter and change in anxiety parameter. The following interaction terms were also entered as grand-mean centered for both parameters: initial anxiety X group, gender X group, initial anxiety X gender and initial anxiety X gender X group.

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}$ (slope) + r_{ij}

Level 2: β_{0j} (trait anxiety at Time 3) = $\gamma_{00} + \gamma_{01}$ (group membership) + γ_{02} (initial anxiety) + γ_{03} (gender) + γ_{04} (initial anxiety X group) + γ_{05} (gender X group) + γ_{06} (initial anxiety X gender) + γ_{07} (initial anxiety X gender X group) + γ_{08} (participation in athletic teams) + μ_{0j}

β_{1j} (change in anxiety over the semester) = $\gamma_{10} + \gamma_{11}$ (group membership) + γ_{12} (initial anxiety) + γ_{13} (gender) + γ_{14} (initial anxiety X group) + γ_{15} (gender X group) + γ_{16} (initial anxiety X gender) + γ_{17} (initial anxiety X gender X group) + γ_{18} (participation in athletic teams) + μ_{0j}

In an attempt to control for additional variables whose existence might also impact the dependent variable (i.e., trait anxiety), each of the following analyses examining Hypothesis 1 were initially conducted while controlling for participation in varsity athletic or intramural teams (given the possible anxiolytic impact of such consistent physical activity). If a particular analysis was found to be significant, a follow-up analysis was conducted, with the inclusion of subsequent control variables, which included: students' participation in a personal (i.e., outside the study) exercise

routine (Time 3), exercise routine frequency (i.e., days per week), exercise routine duration (i.e., average length of exercise bouts), perceived level of fitness, current participation in counseling/psychotherapy for anxiety or depression and current medication treatment for anxiety or depression. As complete data were only available for the 'university athletic team' variable and not for the additional control variables (whose inclusion would subsequently lead to a significant decrease in the sample size for a given analysis), the additional control variables were only used in order to examine the robustness of significant effects and whether or not they remained significant after controlling for

Hypothesis 1 was not supported. Group membership did not significantly predict level of trait anxiety at Time 3, $t(618) = -1.29$, $p = 0.20$, nor rate of change trait anxiety over time, $t(618) = -0.80$, $p = 0.42$. Thus, group membership alone was not associated with either lower levels of trait anxiety at Time 3, or a faster rate of decline in anxiety for the exercise group, as compared to the control group. However, while the association between group and Time 3 anxiety was not significant, there was a trend toward these associations being negative, such that the exercise group may experience lower levels of anxiety at the end of the exercise program relative to the control group.

Hypothesis 1a: Participants' initial levels of anxiety will moderate the association between group membership and level of trait anxiety at Time 3 and rate of change in trait anxiety over time, such that participants with higher levels of initial anxiety will experience (a) lower levels of trait anxiety at Time 3 and (b) a faster rate of decline in trait anxiety over the course of the study (i.e., greater benefits from an exercise program) than participants with lower initial anxiety.

Time 3 anxiety. Hypothesis 1a was supported by the results of the analyses. Initial anxiety significantly moderated the association between exercise program participation and level of trait anxiety at the end of the study, $t(618) = -12.16$, $p < .001$.[1]

Post-hoc analyses suggest that the negative association between group and Time 3 anxiety (which indicates that the exercise group experiences lower levels of anxiety at the end of the study relative to the control group) becomes even greater (i.e., more negative and significant) at higher levels of the moderator (i.e., anxiety at Time 1). Thus, at one standard deviation above the mean level of anxiety in this is a treatment effect, $b = -227.43$, $p < .001$, that is even stronger than at low levels and mean levels of initial anxiety. In addition, the simple effect remained significant both at one standard deviation below the mean, $b = -141.64$, $p < .001$ and two standard deviations below the mean, $b = -98.74$, $p < .001$.

Thus, the exercise treatment was more effective (i.e., participants had lower levels of anxiety at the end of treatment relative to controls) for individuals with higher levels of anxiety at the start of treatment. That is, the treatment worked better for individuals who were more anxious when they entered treatment. Thus group membership is associated with Time 3 anxiety for the majority of the sample (even for participants 2 SDs below the mean level of initial anxiety), but the group effect is stronger for participants who had higher initial levels of anxiety.

Change in anxiety over time. Hypothesis 1a was supported. Initial anxiety level significantly moderated the association between exercise program participation and change in trait anxiety over time, $t(618) = -9.65$, $p < .001$. The association between group and change in anxiety (group effect, $t = -0.93$) was not significant but had a trend toward

being negative such that the treatment group may experience greater decline in anxiety across the study relative to the control group. Significant moderation of group X anxiety revealed that whether or not participants benefited from the treatment (with regard to decline in anxiety over time/improvement over time) depended on their initial level of anxiety when they started the study. That is, it appears that there needs to be sufficient anxiety present to have an impact on, in order for a treatment effect to exist.[1]

Post-Hoc analyses suggest that the negative association between group and change in anxiety over time (indicating that the treatment group experienced greater linear decline in anxiety over time relative to the control group) becomes greater (i.e., more negative and significant) under higher levels of the moderator (i.e., initial anxiety at Time 1). Thus, at one standard deviation above the mean level of anxiety in this sample, there is a treatment effect that is even stronger than at low levels and mean levels of initial anxiety, $b = -2.68$, $p < .001$. In addition, the effect remained significant at both one standard deviation below the mean, $b = -1.67$, $p < .001$ and two standard deviations below the mean, $b = -1.16$, $p < .001$. Thus, group membership is associated with change in anxiety over time for the majority of the sample (even for participants 2 SDs below the mean level of initial anxiety), but the group effect is stronger for participants who had higher initial levels of anxiety.

In sum, participation in the exercise group was associated with lower levels of anxiety at the end of the semester and greater linear decline in anxiety over the course of the exercise program (relative to participation in the control group) to the extent that individuals had higher levels of trait anxiety when they began the study. Alternatively, the exercise program worked best for more anxious students. Of note, although the

control group did experience a modest decrease in anxiety over the course of the study, a subsequent analysis revealed that this decline was not significant, $t(224) = -1.23$, $p = 0.22$.

Hypothesis 1b: Gender will moderate the association between group membership and anxiety, such that women will experience (a) lower levels of trait anxiety at Time 3 and (b) a faster rate of decline in trait anxiety over the course of the study (i.e., greater benefits from an exercise program relative to control participants).

Hypothesis 1b was not supported. Gender did not significantly moderate the association between exercise program participation and the level of trait anxiety at Time 3, $t(618) = 0.98$, $p = 0.33$, nor the rate of change of trait anxiety over time, $t(618) = 1.04$, $p = 0.30$. This analysis indicates that women did not experience a lower level of trait anxiety at Time 3 or a greater linear decline in trait anxiety over time, relative to men. Thus, participation in a chronic program of exercise was equally effective for male and female students. Please refer to Table 5 for the means and standard deviations for STAI-T scores for all participants at all time points. Table 6 displays all relevant effect sizes and percentages of variance accounted for, for all of the effects from the Aim 1 analyses.

Aim 2: Broad Exercise Category

The following analyses were conducted in order to examine the following questions:

(1) Will students participating in a particular broad category of exercise (e.g., cardiovascular, weight-training, Eastern-philosophy-based) experience (a) significantly lower levels of anxiety by the end of the semester (i.e., Time 3 of the present study) and

(b) a greater decline in trait anxiety over the course of the semester (relative to students in other exercise categories)?

(2) Will this broad exercise category effect be stronger for students with higher levels of initial anxiety (i.e., will initial anxiety moderate the effect of broad exercise category on (a) anxiety at the end of the semester and (b) change in anxiety over time)?

and (3) Will the broad exercise category effect by stronger for men vs. women (i.e., will gender moderate the effect of broad exercise category on (a) anxiety at the end of the semester and (b) change in anxiety over time)?

In order to examine the above questions and to examine the possible effect of broad exercise categories, the 19 physical education classes included in the study were divided into three broad categories: cardiovascular activities, weight-training activities and Eastern-philosophy-based activities. Each exercise category was analyzed separately and each analysis included both an exercise category x initial anxiety and an exercise category x gender interaction. Notably, these analyses were conducted with all students in the exercise group (N = 402) and excluded participants in the control group.

As with the previous analyses examining the effects of initial anxiety level and gender, the present analysis of exercise category was conducted while controlling for students' participation in varsity or intramural athletic teams. Due to the previously-discussed inconsistencies and limitations of the exercise and anxiety literature with respect to the effect of exercise type, no hypotheses were offered for these analyses.

Cardiovascular Exercise

The following equation was specified to examine cardiovascular activity predicting both (a) level of trait anxiety at Time 3 and (b) changes in trait anxiety over

time. Cardiovascular activity was entered as uncentered at Level 2. The cardiovascular exercise x initial anxiety and cardiovascular x gender interactions were both entered as grand-mean centered at Level 2.

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}$ (slope) + r_{ij}

Level 2: β_{0j} (trait anxiety at Time 3) = $\gamma_{00} + \gamma_{01}$ (cardiovascular exercise versus other exercise types) + γ_{02} (initial anxiety) + γ_{03} (gender) + γ_{04} (initial anxiety X cardiovascular group) + γ_{05} (gender X cardiovascular group) + γ_{06} (participation in athletic teams) + μ_{0j}

β_{1j} (change in trait anxiety over time) = $\gamma_{10} + \gamma_{11}$ (cardiovascular exercise versus other exercise types) + γ_{12} (initial anxiety) + γ_{13} (gender) + γ_{14} (initial anxiety X cardiovascular group) + γ_{15} (gender X cardiovascular group) + γ_{16} (athletic team participation) + μ_{1j}

Time 3 anxiety. Cardiovascular exercise was marginally significantly related to anxiety at Time 3, $t(395) = -1.71$, $p = .09$, and the interactions of cardiovascular exercise with initial anxiety level, $t(395) = -0.90$, $p = 0.37$, and with gender, $t(395) = 0.19$, $p = 0.85$, were not significant for trait anxiety at Time 3.

Change in anxiety over time. Cardiovascular exercise was also marginally significantly related to rate of change in anxiety over time, $t(395) = -1.701$, $p = .09$, while the interactions of cardiovascular exercise with initial anxiety level, $t(395) = -1.02$, $p = 0.31$, and with gender, $t(395) = -0.28$, $p = 0.78$, were not significant for the change in trait anxiety over time.

Thus, participating in cardiovascular exercise may be associated with lower levels of anxiety at Time 3 and a faster rate of change in anxiety over time, as compared to weight-training and Eastern-philosophy-based exercise and these marginally significant effects were independent of both initial anxiety level and gender.

Weight-Training Exercise

The following equation was specified to examine whether weight-training activity predicted both (a) level of trait anxiety at Time 3 and (b) changes in trait anxiety over time. Weight-training activity was entered as uncentered at Level 2. The weight-training x initial anxiety and weight-training x gender interactions were both entered as grand-mean centered at Level 2.

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}$ (slope) + r_{ij}

Level 2: β_{0j} (trait anxiety at Time 3) = $\gamma_{00} + \gamma_{01}$ (weight-training versus other exercise types) + γ_{02} (initial anxiety) + γ_{03} (gender) + γ_{04} (initial anxiety X weight-training group) + γ_{05} (gender X weight-training group) + γ_{06} (athletic team participation) + μ_{0j}

β_{1j} (change in trait anxiety over time) = $\gamma_{10} + \gamma_{11}$ (weight-training versus other exercise types) + γ_{12} (initial anxiety) + γ_{13} (gender) + γ_{14} (initial anxiety X weight-training group) + γ_{15} (gender X weight-training group) + γ_{16} (athletic team participation) + μ_{1j}

Time 3 anxiety. Participation in weight-training exercise was marginally-significantly associated with anxiety at Time 3, $t(395) = 1.84$, $p = .07$. Neither the weight-training X initial anxiety interaction, $t(395) = 0.191$, $p = 0.85$, nor the weight-training X gender interaction, $t(395) = -0.67$, $p = 0.50$, were significant.

Change in anxiety over time. Participation in the weight-training group was also marginally significantly associated with change in anxiety over time, $t(395) = 1.72$, $p = .09$, such that participating in weight-training exercise tended to be associated with *higher* levels of anxiety at Time 3, as compared to both cardiovascular and Eastern-philosophy-based exercise. Neither the weight-training X initial anxiety, $t(395) = 0.44$, $p = 0.66$, nor the weight-training x gender, $t(395) = 0.18$, $p = 0.86$, interactions were significant with respect to change in anxiety over time.

Thus, students participating in weight-training-related exercise classes did (overall) experience lower levels of anxiety at Time 3 and a significant linear decline in

anxiety over time (compared to the control condition). However, when compared to cardiovascular- and Eastern-Philosophy-Based exercise, weight-training was somewhat less effective with respect to levels of anxiety at Time 3 (i.e., participants had higher levels of anxiety compared to participants in the other exercise groups). Moreover, this tendency of weight-training exercise classes to be associated with higher levels of anxiety at Time 3 (compared to other exercise categories) was independent of both initial anxiety level and gender.

Eastern-Philosophy-Based Exercise

The following equation was specified to examine whether Eastern-philosophy-based activity predicted both (a) level of trait anxiety at Time 3 and (b) changes in trait anxiety over time. Eastern-philosophy-based activity was entered as uncentered at Level 2. The Eastern-philosophy-based activity x initial anxiety and Eastern-philosophy-based activity x gender interactions were both entered as grand-mean centered at Level 2.

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}$ (slope) + r_{ij}

Level 2: β_{0j} (trait anxiety at Time 3) = $\gamma_{00} + \gamma_{01}$ (Eastern-based group versus other exercise types) + γ_{02} (initial anxiety) + γ_{03} (gender) + γ_{04} (initial anxiety X Eastern-based group) + γ_{05} (gender X Eastern-based group) + γ_{06} (athletic team participation) + μ_{0j}

β_{1j} (change in trait anxiety over time) = $\gamma_{10} + \gamma_{11}$ (Eastern-based group versus other exercise types) + γ_{12} (initial anxiety) + γ_{13} (gender) + γ_{14} (initial anxiety X Eastern-based group) + γ_{15} (gender X Eastern-based group) + γ_{16} (athletic team participation) + μ_{1j}

Time 3 anxiety. Eastern-philosophy-based exercise did not significantly predict level of trait anxiety at Time 3, $t(395) = 0.05$, $p = 0.96$. In addition, the Eastern-philosophy-based exercise x initial anxiety ($t(395) = 0.91$, $p = 0.36$)) and Eastern-philosophy-based exercise x gender interactions ($t(395) = 0.39$, $p = 0.70$)) were not significant for Time 3 anxiety.

Change in anxiety over time. Eastern-philosophy-based exercise did not significantly predict rate of change of trait anxiety over time, $t(395) = 0.11$, $p = 0.91$. Likewise, the Eastern-Based exercise X initial anxiety ($t(395) = 0.73$, $p = 0.47$)) and Eastern-Based exercise x gender interactions ($t(395) = 0.03$, $p = 0.97$)) were not significant.

Thus, students in the exercise condition participating in Eastern-philosophy-based classes did not experience lower levels of trait anxiety at Time 3, nor a more rapid decline in trait anxiety over the course of the study, than did students participating in either cardiovascular or weight-training exercise classes. Further, the effect of Eastern-philosophy-based exercise classes on trait anxiety did not differ based upon initial anxiety level or gender. Table 7 displays the means and standard deviations for STAI-T scores for males and females in each broad exercise category. Please refer to Table 8 for all relevant effect sizes and percentages of variance accounted for, for all of the effects from the Aim 2 analyses.

Aim 3: Specific Activity Type

In order to achieve a more fine-grained, yet still meaningful analysis of exercise type, a more specific series of analyses was conducted on each of the specific types of physical activity represented in the study. Thus, the 19 physical education classes included in the study were combined into nine specific physical activity types for analysis: mixed aerobic activities (e.g., cycling, rowing, stair climbing, walking, jogging), weight-training, tennis/racquetball, swimming, yoga, walking/jogging, indoor cycling, martial arts/Tai Chi, stress-reduction and flexibility.

The following analyses were conducted in order to examine these three questions:

(1) Will students engaging in particular exercise activities (e.g., cycling, swimming, jogging/walking, etc.) experience (a) significantly lower levels of anxiety by the end of the semester (i.e., Time 3 of the present study) and (b) a greater decline in trait anxiety over the course of the semester (relative to students in other specific activities)?

(2) Will this specific exercise activity effect be stronger for students with higher levels of initial anxiety (i.e., will initial anxiety moderate the effect of specific exercise category on (a) anxiety at the end of the semester and (b) change in anxiety over time)?

(3) Will the specific exercise activity effect be stronger for men vs. women (i.e., will gender moderate the effect of broad exercise category on (a) anxiety at the end of the semester and (b) change in anxiety over time)?

The following general equation was specified to examine whether participation in each specific exercise activity predicted (a) level of trait anxiety at Time 3 and (b) changes in trait anxiety over time. Separate analyses were conducted for each of the nine specific activities, substituting in the relevant terms for each analysis. Specific activity was entered as uncentered at Level 2, while the interaction of each specific activity with initial anxiety and gender, respectively, were entered as grand-mean centered at Level 2.

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}$ (slope) + r_{ij}

Level 2: β_{0j} (trait anxiety at Time 3) = $\gamma_{00} + \gamma_{01}$ (*specific exercise activity*) + γ_{02} (initial anxiety) + γ_{03} (gender) + γ_{04} (initial anxiety X *exercise activity*) + γ_{05} (gender X *exercise activity*) + γ_{06} (participation in athletic teams) + μ_{0j}

β_{1j} (change in trait anxiety over time) = $\gamma_{10} + \gamma_{11}$ (*specific exercise activity*) + γ_{12} (initial anxiety) + γ_{13} (gender) + γ_{14} (initial anxiety X *specific exercise activity*) + γ_{15} (gender X *specific exercise activity*) + γ_{16} (athletic team participation) + μ_{1j}

As with the preceding analyses of broad exercise category, the analyses of specific activity were initially conducted while controlling for students' participation in

university athletic teams. Significant effects were reanalyzed with the inclusion of the additional control variables. However, due to concerns about extensive missing data for some of these variables, only the 'personal exercise routine' (Time 1), 'current medication' and 'current psychotherapy' variables were used to further examine significant effects.

No hypotheses were offered for the following analyses. As only significant and marginally significant effects are reported below, please refer to Table X for the relevant statistics for all non-significant analyses.

Mixed Aerobic Activity

Time 3 anxiety. Participation in a mixed aerobic exercise class did not significantly predict anxiety at time 3 and the mixed aerobic exercise X gender interaction was non-significant. However, the mixed aerobic exercise X anxiety interaction was marginally significant, $t(395) = -1.92$, $p = 0.06$, indicating that, relative to other specific activity types, participating in a mixed aerobic exercise class may be associated with lower levels of trait anxiety at the end of the study to the extent that individuals started the class with higher levels of anxiety.

Change in anxiety over time. Participation in a mixed aerobic class, as well as the interactions of mixed aerobic exercise with gender and anxiety, respectively, were not significantly associated with the change in trait anxiety over time.

Weight-Training

The original weight-training broad exercise category was based upon a combination of weight-training classes, which included seven individuals enrolled in a mixed aerobic- resistance-training exercise class. In order to form a more pure weight-

training group and thus, a better examination of the effect of exclusive weight-training exercise on trait anxiety, these seven students were eliminated from the present analysis.

Time 3 anxiety. Participation in weight-training classes was marginally significantly associated to anxiety at time 3, $t(395) = 1.88$, $p = 0.06$, while the weight-training X gender and weight-training X anxiety interactions were not significant. The marginally significant association between weight-training participation and time 3 anxiety indicated that participating in the weight-training classes tended to be associated with *higher* levels of anxiety at the end of the semester, relative to all other exercise activity types.

Change in anxiety over time. Participation in weight-training exercise and the interactions of weight-training with gender and initial anxiety, respectively, were not significantly associated with change in trait anxiety over time.

Tennis/Racquetball

Time 3 anxiety. Participation in tennis or racquetball exercise classes was marginally significantly associated with anxiety at time 3, $t(395) = -1.76$, $p = 0.08$. The tennis/racquetball X gender and tennis/racquetball X initial anxiety interactions were not significant. This analysis indicates that participating in tennis/racquetball classes may be associated with lower trait anxiety at the end of the study, relative to other specific activities.

Change in anxiety over time. Neither participation in tennis/racquetball classes, nor the tennis/racquetball interactions with gender or initial anxiety were significant for change in anxiety over time.

Swimming

Time 3 anxiety. Participation in swimming classes, and the swimming X initial anxiety interaction did not predict anxiety at time 3. However, the swimming X gender interaction was significantly associated with time 3 anxiety, $t(395) = 2.62$, $p<.01$).[2]

Although the t-ratio of the interaction was significant, the simple effects yielded by a post-hoc analysis did not reach significance, $b_{women} = -0.01$, $p = 0.99$; $b_{men} = 0.71$, $p = 0.64$, indicating that that swimming as an exercise was not associated with higher or lower levels of anxiety at Time 3 (relative to other types of activity) for men or women.

Change in anxiety over time. Similarly, while participation in swimming and the swimming X initial anxiety interaction did not significantly predict change in anxiety over time, the swimming X gender interaction was found to be significant, $t(395) = 3.46$, $p< .005$.[2]

The non-significant simple effects yielded by a post-hoc analysis for the significant swimming X gender interaction ($b_{women} = -0.01$, $p = -.61$; $b_{men} = 0.01$, $p = 0.84$) again revealed that despite the significant interaction term, swimming was not associated with more or less change in anxiety over time, relative to other exercise activities, for men or women.

Stress Reduction & Flexibility

Time 3 anxiety. Participation in a stress reduction & flexibility class did not significantly predict anxiety at time 3, nor was the stress reduction X gender interaction significant for time 3 anxiety. However, the stress reduction X initial anxiety interaction was significant, $t(395) = 3.26$, $p<.001$.[2]

A post-hoc analysis for the significant stress reduction x anxiety interaction indicated that participating in the stress reduction and flexibility class was associated with

higher levels of anxiety at time 3, relative to all other exercise activities, to the extent that students had higher levels of initial anxiety. Simple effects were significant at one standard deviation above the mean, $b = 47.06$, $p<.001$ and one standard deviation below the mean, $b = 29.23$, $p<.001$.

Change in anxiety over time. As with time 3 anxiety, participation in a stress reduction and flexibility class did not predict change in anxiety over time and the stress reduction X gender interaction was not significant. However, the stress reduction X initial anxiety interaction was significant for change in anxiety over time, $t(395) = 3.97$, $p<.001$.[2]

A post-hoc analysis for the significant stress reduction X anxiety interaction revealed that being in the stress reduction and flexibility class was associated with *less* linear decline in anxiety over time, as compared to the other exercise activities, to the extent that students had higher initial levels of anxiety. The simple effects were significant at one standard deviation above the mean, $b = 0.91$, $p<.001$ and at one standard deviation below the mean, $b = 0.57$, $p<.001$.

Thus, as compared to those in other types of exercise classes, students participating in the stress reduction and flexibility class experienced *less* improvement, as evidenced by a higher level of anxiety at the end of the study and a slower decline in trait anxiety over the course of the study, to the extent that they had higher levels of initial anxiety.

Yoga, Walking/Jogging, Indoor Cycling and Martial Arts/Tai Chi

No significant effects were found for the remaining four specific activities examined; either for Time 3 anxiety or change in anxiety over time. Thus, (as compared

to all of the other specific activities) yoga, walking/jogging, indoor cycling and martial arts/tai chi were not found to be any more or less effective with respect to the level of trait anxiety change by the end of the study or the rate of change in anxiety over time. Moreover, all of the effects of these specific activities were independent of gender and initial anxiety level. Please refer to Table 9 for all of the relevant statistics for each of these activities. Table 10 presents the means and standard deviations for STAI-T scores for participants in each specific activity. Table 11 presents the relevant effect sizes and percentages of variance accounted for, for all of the effects from the Aim 3 analyses.

Supplemental Analyses

The analyses in this section include an examination of the following: the clinical significance of the changes in anxiety experienced by the exercise group, changes in anxiety for both the exercise and control groups at Time 2 (i.e., 5 weeks into the study) and the effect of the exercise program on negative affect, as measured by the Negative Affect scale of the PANAS (Watson, Clark & Tellegen, 1988). Although the following analyses were not originally proposed as part of the current study, they were included because of the additional support and/or context they provide in interpreting the results of the core study analyses.

Clinical Significance

While statistically significant change in trait anxiety was observed in the present study for exercisers (and this rate of change was significantly greater than that experienced by participants in the control group), it was not immediately evident whether the declines in anxiety experienced by the exercise group were actually clinically significant. In order to evaluate the clinical significance of the anxiolytic effect of the

exercise program, a two-step procedure originally proposed by Jacobson and colleagues (Jacobson & Truax, 1991; Jacobson, Roberts, Berns, & McGlinchey 1999; as cited in Fisher & Durham, 1999) was employed. The first step involved the calculation of a "cut-off score" (Fisher & Durham, 1999, p. 1426) on the STAI-Trait scale. The cut-off score indicates the score on an outcome measure that separates the normal range from the clinical range. Using data from the STAI norms as well as from extant literature employing the STAI-Trait scale within anxious populations, Fisher and Durham (1999) calculated this value as 46, such that scores of 46 or higher are indicative of a clinical level of anxiety, while scores of 45 or lower fall in the normal range. The final step of the Jacobson methodology involves the calculation of a Reliable Change Index (RCI; Fisher & Durham, 1999). The calculation of this index yields the minimum number of points' difference between the initial (i.e., Time 1) and final (i.e., Time 3) administrations of the STAI required for observed improvement to be considered statistically significant at the $p < .05$ level. Fisher and Durham (1999) calculated this value to be 8. Thus, in order for the anxiety reduction experienced by a participant in the present study to be considered clinically significant, the participant would (a) need to have had an initial trait anxiety score of 46 or greater and (b) have experienced a decrease in trait anxiety between Time 1 and Time 3 of at least 8 points.

In addition to identifying clinically significant change, Jacobson's procedure can also be used to evaluate whether a participant can be said to have 'recovered' from their clinical anxiety by the end of the study. To achieve recovery, individuals would need to meet the above criteria for clinically significant anxiety decrease *and* would need to have

moved from an initial anxiety score in the clinical range to a final anxiety score in the normal range.

Thus, Jacobson's procedure, as described by Fisher and Durham (1999) allows for an evaluation of two different questions about the clinical significance of the exercise "treatment" in the present study: (1) What proportion of the exercise versus control group participants experienced clinically significant improvement (i.e., declines) in their trait anxiety over the course of the study?, and (2) What proportion of students in each study condition experiencing clinically significant change also 'recovered'(i.e., not only experienced a clinically-significant decrease in trait anxiety, but also moved from an initial anxiety score in the "clinical" range, to a final anxiety score in the "normal" range)?

Exercise Group

One hundred and fourteen of a total of 402 students in the exercise group began the study with trait anxiety scores of 46 or higher. Thus, 28% of the exercise group students initially fell in the clinical range. Seventy-five (66%) of these clinically anxious exercisers experienced declines in trait anxiety change of at least 8 points and thus experienced clinically significant change in trait anxiety. Seventy-two (96%) of the 75 exercisers experiencing clinically significant change (63% of the clinically anxious exercisers) also "recovered," as they moved from the clinically anxious to the normal range of trait anxiety.

Males. Of the 114 clinically anxious exercisers, 41 were male. Thus, 18.6% of all male exercisers initially fell in clinically anxious range. Twenty-five men (61% of the clinically anxious male exercisers) experienced declines in trait anxiety

scores of 8 points or more (i.e., clinically significant change). All of these 25 men "recovered" (61% of clinically anxious male exercisers).

Females. Seventy-three women (18% of all female exercisers) initially fell in the clinical range for trait anxiety on the STAI. Fifty of these women (68.5%) experienced a decline in trait anxiety of at least 8 points (i.e., experienced clinically significant change). Of the 50 women experiencing clinically significant change, 47 (94%, or 63% of all clinically anxious females) "recovered."

Control Group

Sixty-nine out of a total of 225 control students (31%) initially fell in the clinical range of anxiety. By the end of the study, 14 of these 69 students (i.e., 20% of the clinically anxious controls) experienced a clinically significant decrease in anxiety, whereas 66% of the clinically anxious exercisers experienced clinically significant change. Of the 14 control participants experiencing clinically significant change, 11 (16% of the clinically anxious control participants) "recovered."

Males. Eighteen males in the control group (26% of the clinicially anxious control group students) had initial anxiety scores in the clinical range. Of these individuals, five males (28% of the clinically anxious male controls, as compared with 61% of clinically anxious male exercisers) experienced a clinically significant decrease in anxiety from Time 1 to Time 3 of the study. Of the five men experiencing a clinically significant decline, four "recovered" (22% of all clinically anxious male control participants, as compared with 61% of male exercisers).

Females. Fifty-one females in the control group (74 % of the clinically anxious control group students) had initial anxiety scores which fell in the clinical range.

Of these 51 anxious female control participants, nine (18% of the clinically anxious female controls) experienced a clinically significant decrease in anxiety from Time 1 to Time 3. Of these nine women, six (12% of the clinically anxious female control participants, as compared with 63% of female exercisers) moved from the clinical anxiety range at Time 1 to the non-clinical range at Time 3 and could thus be considered "recovered."

In sum, the semester-long program of chronic exercise implemented in the present study appeared to have clinically significant anxiolytic benefits for both males and females. To rule out the possibility that concurrent psychotherapy and/or psychiatric medication could have accounted for the different rates of clinically significant change between the exercise and control groups, the percentage of clinically anxious exercisers and controls partaking in medication or therapy was calculated. Seven percent of clinically anxious exercisers and 11% of clinically anxious controls were engaged in concurrent psychotherapy, and 6% of clinically anxious exercisers and 6% of clinically anxious controls were taking psychiatric medication (data for these questions was not provided by 9 clinically anxious exercisers nor by 7 clinically anxious controls). As equivalent percentages of students in both the exercise and control groups were taking psychiatric medications, and as slightly more control than exercise participants were receiving psychotherapy during the course of the study, the fact that a greater percentage of exercise participants experienced clinically significant change cannot be attributed to these factors. These results provide even stronger support for the idea that a program of regular exercise can significantly benefit individuals with clinical anxiety. In an attempt to provide a graphical display of the group X initial anxiety interaction described above,

Figure 1 shows the mean trait anxiety (group) trajectories for exercise and control participants whose Time 1 trait anxiety fell in the clinical range. Note: clinically significant change and recovery status were not taken into account in this graph.

Time 2 Anxiety

As a follow-up to the significant group X initial anxiety interaction for anxiety at Time 3, an analysis was conducted in order to examine levels of trait anxiety at the midpoint (i.e., Time 2) of the study. Thus, the same analysis from the Hypothesis 1a analysis was conducted, but the intercept was redefined to correspond to level of anxiety at Time 2 instead of Time 3 ("time" was measured as days since Time 2 in order to model the intercept as the midpoint of the semester). As an analysis of the group X initial anxiety interaction for change in anxiety over time (corresponding to Time 2) would have yielded the same result as for the earlier examination of change over time for Time 3, this aspect of the earlier analysis was not repeated. No hypothesis was examined.

The following equation was specified to examine exercise program participation as a predictor of level of trait anxiety at the midpoint of the study (i.e., Time 2). Group membership and gender (dichotomous variables) were entered as uncentered at Level 2 as predictors of both of these parameters. Initial anxiety (i.e., Time 1 trait anxiety score), a continuous variable, was entered as grand-mean centered for both the time 2 anxiety and change in anxiety over time. The following interaction terms were also entered as grand-mean centered for both parameters: initial anxiety X group, gender X group, initial anxiety X gender and initial anxiety X gender X group.

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}$ (slope) $+ r_{ij}$

Level 2: β_{0j} (trait anxiety at Time 2) $= \gamma_{00} + \gamma_{01}$ (group membership) $+ \gamma_{02}$ (initial anxiety) $+ \gamma_{03}$ (gender) $+ \gamma_{04}$ (initial anxiety X group) $+ \gamma_{05}$ (gender X group) $+ \gamma_{06}$ (initial anxiety X gender) $+ \gamma_{07}$ (initial anxiety X gender X group) $+ \gamma_{08}$ (participation in athletic teams) $+ \mu_{0j}$

Initial anxiety significantly moderated the association between exercise program participation and level of trait anxiety at the midpoint of the study, $t(618) = -13.29$, $p < .001$. Being in the exercise group was associated with lower levels of anxiety at Time 2 (i.e., 5 weeks into the study), relative to being in the control group and this effect was more pronounced for students with higher levels of initial anxiety. Thus, by as early as 5 weeks into the study, exercise participation was more effective (with respect to the level of trait anxiety at 5 weeks) than participation in the control group to the extent that exercisers had higher levels of initial anxiety at the beginning of the study. A post-hoc analysis revealed that this effect was significant at both one standard deviation above ($b = -133.34$, $p<.001$) and one standard deviation below the mean, $b = -83.07$, $p<.001$. Table 12 presents all relevant effect sizes and percentages of variance accounted for, for the analysis of anxiety at Time 2.

Effect Size Comparison between Trait Anxiety Change at Time 2 and *Time 3*

The respective effect sizes for the simple effects for group membership predicting trait anxiety at Time 3 and group membership predicting trait anxiety at Time 2 (at one standard deviation below the mean level of initial anxiety) were compared using an online calculator (DeCoster & Leistico, 2005). No significant difference between the effects was found for decrease in anxiety at Times 2 (i.e., 5 weeks) and Time 3 (i.e., 10 weeks), $z = -0.63$, $p = 0.53$. This indicates that the extent to which levels of anxiety differed for exercisers versus control participants was similar at both Time 2 and Time 3; however, continued participation in the exercise group resulted in further improvement over time as evidenced by results of Hypothesis 1a, with respect to change in anxiety

over time (i.e., group membership was also associated with linear decline in anxiety over time).

Negative Affect

In order to examine whether the effect of participation in an exercise program was specific to trait anxiety or whether it might impact a more general negative affect factor, the group X gender X initial anxiety analysis was repeated (see Hypothesis 1a). The following equation was specified to examine exercise program participation as a predictor of (a) level of negative affect at the end of the study (i.e., Time 3) and (b) changes in negative affect over time. Group membership and gender (dichotomous variables) were entered as uncentered at Level 2 as predictors of both of these parameters. Initial anxiety (i.e., Time 1 trait anxiety score), a continuous variable, was entered as grand-mean centered for both the time 3 negative affect and change in negative affect over time. The following interaction terms were also entered as grand-mean centered for both parameters: initial anxiety X group, gender X group, initial anxiety X gender and initial anxiety X gender X group.

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}$ (slope) + r_{ij}

Level 2: β_{0j} (negative affect at Time 3) = $\gamma_{00} + \gamma_{01}$ (group membership) + γ_{02} (initial anxiety) + γ_{03} (gender) + γ_{04} (initial anxiety X group) + γ_{05} (gender X group) + γ_{06} (initial anxiety X gender) + γ_{07} (initial anxiety X gender X group) + γ_{08} (participation in athletic teams) + μ_{0j}

β_{1j} (change in negative affect over the semester) = $\gamma_{10} + \gamma_{11}$ (group membership) + γ_{12} (initial anxiety) + γ_{13} (gender) + γ_{14} (initial anxiety X group) + γ_{15} (gender X group) + γ_{16} (initial anxiety X gender) + γ_{17} (initial anxiety X gender X group) + γ_{18} (participation in athletic teams) + μ_{0j}

Time 3 negative affect. While the main effect of group predicting negative affect was not significant, initial anxiety significantly moderated the association between exercise program participation and level of negative affect at the end of the study, $t(617)$

= -11.33, p<.001.[4] As with the original analysis examining trait anxiety at Time 3, the results of this analysis indicates that being in the exercise group was associated with lower levels of negative affect at the end of the study, relative to being in the control group to the extent that exercise group participants had higher levels of initial anxiety.

Change in negative affect over time. Likewise, while the main effect of negative affect was not significant, initial anxiety also significantly moderated the association between exercise program participation and change in negative affect over time, $t(617) = -9.73$, $p<.001$.[3] As with the examination of changes in trait anxiety over time, the significant group X initial anxiety interaction indicates that being in the exercise group was associated with greater linear decline in negative affect over time, relative to being in the control group, to the extent that exercise participants had higher levels of initial anxiety. Please refer to Table 13 for all relevant effect sizes and percentages of variance accounted for, for the analysis of negative affect.

Discussion

Hypothesis 1: Students participating in the exercise group will experience (a) significantly lower levels of anxiety by the end of the semester (i.e., Time 3 of the present study) relative to the control group and (b) a greater decline in trait anxiety over the course of the semester relative to students in the control condition. Further, this treatment effect will be stronger for individuals with higher levels of initial anxiety (i.e., initial anxiety will moderate the effect of treatment group versus control group on (a) anxiety at the end of the semester and (b) change in anxiety over time).

As predicted, and consistent with previous literature (e.g., Petruzzello et al., 1991), participation in a semester-long program of physical exercise was associated with

both lower levels of trait anxiety at the end of the semester and a significantly *greater decline* in trait anxiety over time relative to participation in the control condition, and this pattern of results was stronger for individuals with higher levels of initial anxiety. A significant group (exercise versus control) by initial anxiety interaction was detected, such that the anxiolytic effect of chronic exercise was most pronounced for exercisers with higher initial anxiety. This finding is consistent with previous meta-analyses (e.g., Petruzzello et al., 1991) that described a moderating effect of initial anxiety on the exercise-anxiety association.

Several aspects of the findings for Hypotheses 1 are of special note. First, while the anxiolytic effects of exercise were most pronounced for individuals with higher initial anxiety, they remained significant for individuals with as low as -2.0 standard deviations *below* the mean level of initial anxiety. This indicates that the majority of students participating in an exercise program are expected to experience significant decline in trait anxiety, even when starting the program with nominal levels of anxiety. Second, significant improvement in trait anxiety for the exercise group relative to the control group was already evident by Time 2, such that by five weeks after the initial assessment, participants in the exercise group had already experienced a significant trait anxiolytic effect (i.e., levels of anxiety at Time 2 were significantly lower for the exercise group compared to the control group and this effect was more pronounced for individuals with higher initial levels of anxiety). The fact that anxiety levels continued to decrease at a more rapid rate for the exercise group compared to the control group during the final five weeks of the program suggests that participation in the program continued to have anxiolytic effects, which is consistent with the results of meta-analysis (e.g., Petruzzello

et al., 1991). Finally, these findings were robust enough to remain significant after taking into account a number of potential confounding variables, including involvement with an athletic team, participation in a personal exercise routine outside of the study-related exercise class, concurrent psychotherapy, and psychiatric medication.

As discussed earlier, previous reviews (e.g., Landers & Petruzzello et al, 1994; Long & von Stavel, 1995; Stich, 1998) have found evidence that higher-anxious samples experience more significant declines in trait anxiety as a result of exercise program participation than lower-anxious samples. However, these findings were based on the authors' examinations of *clinical samples* (e.g., psychiatric patients). As the current study involved a "normal" (i.e., non-clinical) sample, anxiety scores were likely more normally distributed and less negatively skewed than would be expected in a clinical sample. With fewer participants at the high-anxious end of the spectrum than in studies with clinical samples, it is especially noteworthy that an effect of initial anxiety was detected. This suggests that the anxiolytic benefits of a chronic exercise program can be experienced even by individuals within the normal range of anxiety, thus expanding the scope of the target audience for these results.

To this author's knowledge, no previous studies of chronic exercise and anxiety have examined the rate of change in trait anxiety over the course of an exercise program. The results of this study demonstrated that chronic exercise not only can lead to a significant decrease in trait anxiety, but that the rate of this decline can be affected by individuals' initial levels of anxiety, such that individuals with higher initial anxiety experience more rapid declines in anxiety levels. This suggests that exercise may be an effective component of treatment for anxiety, and more specifically that highly anxious

individuals, who are most in need of anxiety reduction, can expect to experience the fastest improvement. While it is possible that some of this improvement may be attributable to regression to the mean, the fact that highly anxious individuals in the control group did not experience the same declines in anxiety over the same time period suggests that this phenomenon cannot solely account for the observed effects.

The inclusion of relevant and potentially confounding control variables in the present study, as well as the fact that the treatment effect of exercise remained significant when incorporating these variables into the analyses, represents an important contribution to the exercise and anxiety literature. Previous authors either have not attempted to control for such variables, have not controlled for this many relevant variables, or have not done so in the manner employed in the present study (i.e., using growth curve modeling procedures). Given that random assignment was not possible in the current study, the fact the findings remained significant even when controlling for these factors is especially significant. Additionally, students in both the exercise and control conditions of the present study were free to participate in their own exercise regimen outside of class. This aspect of the study was potentially threatening to the ability to detect significant results, in that control group participants were theoretically eligible to experience the anxiolytic benefits of exercise through participation in their own self-directed exercise routines. Therefore, the fact that a significant group effect was detected suggests that the consistency provided by the structured exercise program (where students were required to exercise two to three times per week) may have been a necessary component of the treatment effect.

In sum, exercisers experienced a significant positive change in trait anxiety over the course of a semester-long exercise program, and participants' initial level of anxiety affected both the *rate* of this change and the levels of anxiety that participants ultimately experienced at the end of the program. These effects were so robust and pervasive that they extended to almost the *entire* sample of exercisers. Further, the anxiolytic effects of exercise were already detected by the midpoint of the study.

Hypothesis 2: Women in the exercise group will experience a greater degree of anxiety reduction than men.

As research regarding anxiety disorders has indicated that women are more likely than men to experience anxiety and to be diagnosed with an anxiety disorder (Craske, 1999), and as initial anxiety has been found in previous meta-analyses of the exercise and anxiety literature to moderate the effect of exercise on anxiety, it was predicted that women in the present study would experience a greater anxiolytic benefit of exercise than would men. Contrary to this hypothesis, the lack of a significant group by gender by initial anxiety interaction indicated that gender did not moderate the treatment effect, even for exercisers with higher levels of initial anxiety. A simple follow-up *t*-test comparing initial anxiety level for men versus women was not significant and indicated that men and women in the exercise groups did not differ with respect to their initial anxiety levels. Additional tests at subsequent study time points also found no gender difference in trait anxiety. Women and men did not differ with regard to the treatment effect (i.e., greater change in trait anxiety over time and less anxiety at the end of the semester for the exercise group versus control group). Thus, overall, there was no

evidence that a program of exercise was disproportionately beneficial for women versus men.

One possible explanation for this result is that while women may be more likely to be diagnosed with an anxiety disorder, similar levels of trait anxiety may actually be present in men and women, especially in non-clinical samples like that of the present study. Since initial anxiety moderates the exercise-anxiety association, it would make sense that men and women would experience similar benefits from participating in an exercise program (relative to a control condition) to the extent that their initial anxiety levels are similar.

Exercise Category Analyses

Regarding the trait anxiolytic impact of various broad categories of exercise, the marginally significant effects indicated that being enrolled in a physical education class emphasizing cardiovascular activity was associated with lower levels of trait anxiety at Time 3 and a more rapid decline in trait anxiety, as compared to participation in weight-training or Eastern-philosophy-based forms of exercise. This marginally significant effect was independent of both gender and initial anxiety level.

The marginally significant effects for weight-training indicated that students participating in weight-training activities experienced less of a decrease in trait anxiety and a slower rate of decline than students participating in cardiovascular or Eastern-philosophy-based physical activity. As with cardiovascular exercise, these effects were independent of both gender and initial anxiety level. The findings are somewhat consistent with the extant literature, as some studies, reviewed by Landers and Petruzzello (1994) have found weight-training to actually result in an *increase* in anxiety.

The results of the present analyses suggest that weight training may not be as effective in reducing trait anxiety as is cardiovascular activity, but it is not anxiogenic.

There were no significant effects of Eastern-philosophy-based physical activity regarding either the level of anxiety at Time 3 or the rate of change over the semester. Thus, while students enrolled in exercise classes involving Eastern-philosophy-based physical activities did experience a significant decline in trait anxiety over the course of the study, this effect was not significantly different than that experienced by students engaged in cardiovascular or weight-training activities.

Overall, these findings suggest that cardiovascular exercise may tend to be more effective than other exercise categories with respect to decreasing trait anxiety. The findings also suggest that weight-training may, in general, not be as effective for reducing anxiety. However, as neither of these findings actually reached statistical significance, they are best interpreted as trends or suggestions of effect and therefore require further investigation.

Specific Exercise-Type Analyses

Of the nine analyses conducted to examine the anxiolytic impact of specific types of exercise (i.e., walking/jogging, aerobic conditioning, weight training, swimming, cycling, racquet sports, yoga, tai chi/martial arts, and stress reduction/flexibility), several significant results emerged.

Results from the weight-training classes (which included free-weights and weight machines) indicated that weight-training was marginally significantly associated with higher levels of anxiety at the end of the semester, relative to all other types of exercise. In contrast, participation in racquet sports was marginally significantly associated with

lower levels of anxiety relative to all other types of exercise. While Time 3 anxiety level was significantly associated with participation in these forms of exercise, there was no significant relationship with rate of change in anxiety for either exercise type.

Participation in yoga, walking/jogging, martial arts, swimming, or cycling was not associated with any significant effects for Time 3 anxiety or rate of change in anxiety over the course of the semester. This indicates that these types of activities were equally effective at reducing anxiety.

A significant class by initial anxiety interaction for both Time 3 anxiety and rate of change in anxiety was detected for the Stress Reduction and Flexibility course, which involved meditation and relaxation training, among other activities. Specifically, participation in this class was associated with higher levels of anxiety at Time 3, relative to all other exercise classes, especially for higher-anxious individuals. Participation in this course was also associated with a less rapid decline in anxiety than was experienced in other fitness classes, with the slowest rates of change evident for the most anxious individuals.

Though little previous research exists in terms of comparing specific types of exercise, the findings of the present study are generally consistent with the extant literature, in that cardiovascular activity in general has been found to reduce anxiety, while the evidence for weight-training activity is less consistent and has sometimes found weight-training to increase anxiety. However, to the author's knowledge no previous studies have specifically examined the effects of such sports as tennis and racquetball, which are quite different from activities such as walking, jogging, or aerobics, due to both the competitive aspect and the skills-based (e.g., hand-eye coordination, proper

stroke and form, etc.) components involved in these activities. Regarding the results for the stress reduction and flexibility class, it is possible that the reason this class was least effective at reducing anxiety was because it was the least "active" of all of the fitness classes. The curriculum for this class involved some flexibility training, which is physical in nature, but also involved students learning about effective time management, meditation, coping with academic and peer pressure, depression, anger, and phobias. It should also be noted that mean anxiety scores for students in this class did decrease overall from Time1 to Time 3.

Clinical Significance

The semester-long program of chronic exercise implemented in the present study appeared to have clinically significant anxiolytic benefits for both males and females, in that a much greater proportion of clinically anxious exercisers experienced clinically significant change as compared to clinically anxious controls. Given the fact that roughly equivalent percentages of exercisers and controls were participating in psychotherapy and/or taking psychiatric medications over the course of the semester, it is unlikely that these factors accounted for the different rates of clinically significant change between the exercise and control groups.

Contributions of the Present Study

Several characteristics of the present study represent significant contributions to the exercise and anxiety literature. First, the large sample size allowed for more than adequate power to compare changes in trait anxiety over time between the exercise and control groups, to examine the impact of initial anxiety level, to evaluate potential gender differences, to examine the impact of three broad categories of exercise on trait anxiety,

and to examine specific types of exercise. Second, to the author's knowledge, no previous studies of the effect of chronic exercise on trait anxiety have employed Growth Curve Analysis (GCA) to analyze the data. GCA techniques used in the present study allowed for an examination of both change in trait anxiety over time and the *rate of change over time*, which has not previously been examined. Being able to draw conclusions about the rate of change in trait anxiety over time has potential clinical implications, in that it suggests that physical exercise may be an effective and relatively fast-acting adjunct to psychotherapy and medication for patients with anxiety. Furthermore, as previously discussed, GCA does not have the same degree of inherent bias as do the mean-based analysis of variance (ANOVA) procedures typically used to analyze data in this field of study.

Third, in contrast to most studies of exercise and anxiety, which have typically focused on two or three specific types of exercise, such as weight training and running, the present study sampled participants from 9 different specific types of physical activity, divided into three broad categories (i.e., cardiovascular, strength-training, and Eastern-philosophy-based). This provided a diverse sample of exercises on which to examine the anxiolytic effect of exercise. The results of the present study suggest the effectiveness of many different types of physical activity for reducing anxiety.

Fourth, the ecological validity of the present study was enhanced by several aspects of the study's design. First, while random assignment to either the exercise or control condition or to specific exercise classes was not possible, the fact that students self-selected into their specific exercise class (presumably by selecting activities in which they were interested or preferred) is an asset of the present study in that it more closely

represents what individuals are likely to do in the real world when they begin an exercise program. Furthermore, as people are more likely to regularly engage in types of exercise that they enjoy (Abernethy, Mackinnon, Kippers, & Hanrahan, 2004), individuals would be more likely to partake in a treatment and thus experience its benefits if they are free to select an activity based on their preferences.

Fifth, another asset of the present study that enhances ecological validity is the fact that no restrictions were placed on participants in either the exercise or control group with respect to their participation in either university or intramural athletic teams or personal exercise routines. Thus, students in the control group were free to exercise in any way they chose, and students in the exercise group were free to participate in any forms of exercise in addition to their study-related physical education class. While one method of managing the issue of the potential influence of outside exercise on study results might be to request that control group participants not exercise for the duration of the study, and/or that exercise group participants not engage in any additional physical activity outside of their study-related exercise program. Given that it is possible that additional exercise outside of their study-related class might result in an exaggerated decrease in exercisers' trait anxiety relative to what could have been found from class participation alone, and that the participation of control group members in personal exercise programs could have made it more difficult to detect a treatment effect, it is understandable that researchers would want to control for these variables in some way. In the present study, students were asked brief questions about the degree and nature of any "personal exercise routines" they engaged in during the study and about their potential participation in university or club-related athletic teams. Questions about

exercise were brief but targeted and very amenable to analysis. As with allowing students to self-select into their exercise classes, neither requesting nor requiring participants to abstain from additional exercise made for a more "naturalistic" and ecologically valid investigation.

Sixth, previous studies of the effect of exercise on anxiety have typically examined only aerobic and/or non-aerobic exercise. Given the popularity and widespread availability of more "Eastern-philosophy based" exercise (e.g., Tai Chi, Yoga, martial arts), and given that some research exists supporting the potential anxiolytic impact of these forms of exercise, the present study incorporated several such "Eastern-philosophy-based" types of physical activity. This allowed for a direct comparison of the anxiolytic impact of this category of activity with more traditional cardiovascular (e.g., running, cycling, walking) and weight-training activities.

Seventh, the semester-long (i.e., 13-14 weeks of exercise) duration of the present study represented a longer-duration exercise program than has been employed in the majority of studies in the exercise and anxiety literature. This aspect of the study's design allowed for an investigation of the effects of exercise over a longer period of time than typically studied (Time 1 to Time 3 represented a 10-week time span), and it also made the inclusion of more than two data points more informative. Specifically, the inclusion of a data point in the middle of the study allowed for a more precise analysis of exercise-induced anxiolysis. In the present analyses, rate of change over time could be assessed, and the fact that differences between exercisers and control participants existed by Time 2 and increased by Time 3 was identified, suggesting a moderating influence of program duration.

Eighth, in the present study, both the exercise and control groups were composed of university students, which made it more likely that participants in the two conditions would be similar on various demographic factors, such as stage of life, academic-related stressors, daily schedule, access to exercise classes and equipment at the university physical education center, and amount of time for exercise. While control group participants were predominantly freshmen and the class rank of the exercise participants was more diverse, there is no reason to believe that this difference would have affected the degree to which participants would benefit from exercise.

Finally, the ability to draw conclusions about the potential for chronic exercise to bring about clinically significant declines in anxiety for anxious individuals was enhanced by the fact that factors such as concurrent psychotherapy and psychiatric medication were accounted for. The fact that significant declines in anxiety were detected even when controlling for these factors lends strength to the conclusions that exercise has an anxiolytic effect.

Limitations

While the present study included a number of improvements over past research attempts, it also possessed some limitations. For example, only a single measure of trait anxiety was employed, rather than incorporating multiple modalities of trait anxiety assessment, such as other self-report questionnaires, observer reports, or physiological measures. It is possible that there is something about the specific item content or other properties of the STAI that resulted in the study's findings, and that different results may have emerged if trait anxiety had been assessed in other ways. Furthermore, Fisher and Durham (1999) discuss some of the limitations of the STAI-T as a measure of trait

anxiety, specifically that, "changes in the uncontrollable nature of worry, and in the somatic symptoms associated with high levels of arousal, vigilance, and motor tension, are not assessed by the STAI-T" (p. 1428).

Similarly, although the present study focused primarily on the effect of chronic exercise on trait anxiety (and to a lesser extent, negative affect), exercise participation may have also had other comparable psychological impacts (e.g., such as on depressive symptomotology), which were not fully assessed. The significant decrease in negative affect in the exercise group provides some evidence of such a broader psychological impact. That depressive symptomotology might have also been affected in this study is not unexpected, given the well-documented effect of exercise on depression (Petruzzello & Motl, 2006), as well as the well-known link (i.e., comorbidity) of anxiety and depressive disorders (Barlow, 2002). Given the absence of a significant difference between the negative affect and trait anxiety effect sizes, perhaps the effect on depressive symptoms in the present study (had this been assessed) might also have been comparable to the effect on trait anxiety.

In addition, given the empirical attention such additional personality constructs as self-esteem, self-efficacy and locus of control have received as potential psychological mechanisms of the anxiolytic effect of exercise on anxiety (e.g., Petruzzello & Motl, 2006), a significant impact on these other variables might have also been found, had they also been assessed.

With respect to the timing of the study questionnaires, the fact that the initial data point in the present study was not a true "pre-exercise" point represents an additional limitation of the study. Time 1 measures of anxiety were completed by participants

approximately two to three weeks after the start of their exercise classes. While actual exercise programs did not begin in earnest until the second or third week of class, students had begun attending class and, in most cases, had some initial training sessions prior to completing Time 1 questionnaires. Thus it is possible that the level of anxiety indicated at their initial study time point could have been different from their true "pre-program" anxiety level. Given that this study deals with trait anxiety, however, which is by definition a more enduring characteristic than state anxiety, it is unlikely that several bouts of exercise prior to Time 1 would have effected a significant reduction. If anything, it would be reasonable to hypothesize that initial anxiety might have already been somewhat reduced by students' participation in a structured exercise program for a few weeks prior to Time 1, in which case the anxiolytic impact of exercise detected in the present study might have been even greater.

The use of online data collection, while likely the most convenient for the participants and almost certainly a contributing factor to the ability to recruit such a large sample, may also represent a limitation of the present study. Specifically, the principal investigator had little control over when and under what conditions the students completed the questionnaires. As such, there was no standardization of the time of day or surrounding environment for data collection. Some participants may have completed the measures at a time when they were very alert, in a quiet environment, and focused purely on giving an accurate assessment of their level of trait anxiety, while others have may have completed the measures when they were tired and amid ongoing distractions (e.g., friends, television, music). Unfortunately, it is not possible to assess the extent to which

this might have influenced study results. It is hoped that the large sample size helped to control for this factor.

Future Directions

Results of the present study suggest several avenues for future research in this area. First, given the fact that anxiety had decreased significantly in this sample after five weeks of exercise, and that the declines became more pronounced by 10 weeks, it seems important to extend the duration of the study to determine the point at which maximum anxiety-related benefit is reached, and whether this treatment effect remains stable over time if exercise is continued. Questions such as whether changes in the characteristics of the exercise program (e.g., increase in intensity and/or bout duration, type of physical activity) are necessary to maximize or maintain benefits could be explored. It would also be interesting to examine how long the anxiolytic effects of a chronic exercise program last after exercise is terminated, using several follow-up data points at regular intervals after the structured exercise program ends (since we are already aware from the results of the control group in the present study that allowing individuals the choice to pursue exercise on their own without a structured program did not produce anxiety-related benefits).

Nearly one-third of the participants in the present study had Time 1 STAI scores above the cut-off point for clinical anxiety, and most of the clinically anxious exercisers experienced clinically significant improvement over the course of the study. Given the aforementioned limitations of the STAI, however, it could be advisable to recruit a sample of participants who were determined to be clinically anxious through other means (e.g., clinical interview at the university counseling center or student health service), and

to see whether the same results were obtained. Specifically recruiting clinically anxious participants would also provide a sample with more individuals at very high levels of anxiety and therefore allow for an examination of how exercise would impact individuals in this very highly anxious subgroup.

An ideal future study would evaluate potential physiological and psychological mechanisms of the anxiolytic effect of exercise. One potential mechanism of this effect that has received some attention in the literature is self-efficacy (SE), or the related construct of locus of control (LOC). An efficient way to assess this potential mechanism would be to include a measure of locus of control or self-efficacy at each study time point. Analyses could then examine the change in this variable over time concurrently with change in trait anxiety. Doing so could help to answer the following questions: (1) What is the nature of the relationship between LOC/SE and trait anxiety in university students?, (2) How do these constructs change over time during participation in a program of chronic exercise?, (3) Do certain types of exercise exert a greater impact on LOC/SE?, (4) Are there gender differences in changes in LOC/SE over the course of an exercise program?, (5) Does LOC/SE function as a moderator or mediator in the relationship between chronic exercise and trait anxiety?, and (6) Does moderation/mediation *only* take place for exercisers with clinically significant anxiety?

Implications for Universities

One major implication of the present study revolves around the importance of university-based physical education courses for student physical and mental health. As all students in the present study had equal access to the same university-based physical fitness facilities, and as control participants were free to exercise as they chose, the fact

that greater and more rapid declines in trait anxiety were experienced by students enrolled in physical education classes suggests that some characteristic(s) of physical education classes may be factors in the obtained results. One possibility is that the structure provided by these programs (e.g., accountability for attendance, regularly scheduled classes 2-3 times per week, instruction on proper exercise technique) or the social aspect of exercising with peers, which may contribute to motivation and/or enjoyment, made it possible for students to participate consistently in exercise and thus allowed the exercise to exert its anxiolytic effect, whereas individuals not enrolled in a structured program may not have exercised consistently enough to experience the anxiety-related benefits.

Although not assessed in the present study, a program of chronic exercise such as those provided by university physical education classes may also have academic benefits for students. Given that a characteristic of generalized anxiety is difficulty concentrating (American Psychiatric Association, 2000), clinically significant declines in trait anxiety such as those experienced in the present study may allow students to focus more effectively on their studies.

Conclusion

Overall, the results of the present study support findings from previous literature that a program of chronic exercise is associated with significant declines in trait anxiety. The use of a control group, particularly one that was free to exercise at will at the same facilities, a large sample size, multiple waves of data, growth curve analytic techniques, relevant control variables, and an examination of clinical significance lend strength to these conclusions and indicate that exercise should probably be part of the standard

treatment for trait anxiety. The ability to examine three broad categories of exercise and nine specific exercise types, which indicated overall that nearly all types of exercise have anxiolytic effects, makes these findings more useful in practice. Specifically, anxious individuals can feel free to choose the types of physical activities they prefer, and are thus more likely to engage in over time, and thus will be more likely to experience anxiety-related benefits.

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Appendix A

Emory University
Department of Psychology
Informed Consent Form

Title: The role of gender and exercise type in the effect of chronic exercise on trait anxiety in college students

Principal Investigator: Michael T. Rothman, M.A.

Faculty Advisor: Stephen Nowicki, Ph.D.

Participant Requirements: Individuals must be **at least 18 years of age** or older in order to participate.

Purpose: The purpose of the study is to examine the psychological effects of exercise in a sample of approximately 200 undergraduate students at Emory University. The study will involve the completion of a series of brief questionnaires at three times during the course of the semester.

Procedures: You will be asked to complete 2-4 short online questionnaires at the beginning, middle and end of the semester, as well as to maintain and submit a brief bi-weekly log of your exercise participation during the course of the semester. The total anticipated amount of time needed for participation in the study is approximately 1.5 hours (approximately 30 minutes for each set of questionnaires) plus 1 hour total over the semester to complete your exercise log, for an *overall total of approximately 2.5 hours* over the course of the semester.

Risks: You may experience some slight discomfort stemming from the nature of some of the questionnaire items.

Benefits: You may not benefit directly from this study. Potential societal benefits include increased knowledge/understanding about how physical exercise may affect psychological functioning.

Compensation: All participants will receive either *2 extra credit points* (Phys. Ed & Health class students only) or *2 research credits* (Introduction to Psychology students only).

Voluntary Participation and Withdrawal: Participation in this study is voluntary. You have the right to refuse to be in this study. Participation in this study will not in any way affect your grade or class standing in the particular academic class from which you are volunteering. If you decide to participate in the study and change your mind, you

have the right to drop out at any time. Feel free to skip any questions on any questionnaire that you do not feel comfortable answering.

Confidentiality: We will keep all facts about you private. We will keep your records private to the extent allowed by law. We will use a participant identification number rather than your name on all study records where we can. Your name and other facts that might identify you will not appear when we present this study or publish its results.

Contact Persons: Call Michael Rothman (404) 626-6084 or Dr. Stephen Nowicki, (404) 727-7454 if you have questions about this study. If you have any questions about your rights as a participant in this study, please call the Emory University Institutional Review Board at (404) 712-0720 or toll free at 1-877-503-9797.

We will give you a copy of this consent form to keep. If you are willing to volunteer for this research, please sign below.

_____ _____ _____

Name Date E-mail Address

_____ _____

Principal Investigator Date

Appendix B

Exercise Expectancy Questionnaire

1. Which of the following benefits do you expect to gain from taking this physical education class? (please check all that apply):

___ Improve my physical fitness
___ Fulfill a university requirement
___ Reduce stress
___ Lose weight
___ Improve my physical appearance
___ Meet people
___ Improve my muscular strength
___ Improve my endurance
___ Learn about proper exercise training techniques
___ Establish a consistent program of exercise to follow in the future
___ Feel better about myself
___ Challenge myself
___ all of the above
___ other : _____

2. Which of these benefits is your PRIMARY reasons for taking this class?

_____

Please answer the following questions on the following scale:

1	2	3	4	5
Not at all	Somewhat	Moderately	Very much	Extremely

As a result of this class, how much do you expect to….

3. Improve your cardiovascular functioning?

1	2	3	4	5

4. Reduce your stress?

1 2 3 4 5

5. Improve your muscular strength?

1 2 3 4 5

6. Feel better (about yourself)?

1 2 3 4 5

7. Improve your mood?

1 2 3 4 5

8. Build muscle?

1 2 3 4 5

9. Feel better?

1 2 3 4 5

10. Look better?

1 2 3 4 5

Footnotes

[1]This effect remained significant after a reanalysis controlling for students' personal exercise routine (Time 3), exercise routine frequency, exercise routine duration, fitness level, current medication status, and psychotherapy participation.

[2]This effect remained significant after a reanalysis controlling for participants' personal exercise routine (Time 1), medication status, and psychotherapy participation.

[3]This effect remained significant after a reanalysis controlling for personal exercise routine (Time 3), exercise routine frequency, exercise routine duration, medication status, and psychotherapy participation.