

EFFECTS OF AEROBIC EXERCISE ON CARBON DIOXIDE REACTIVITY AMONG
INDIVIDUALS WITH HIGH ANXIETY SENSITIVITY

A Thesis

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FOREWORD

This thesis is written in accordance with the style of the *Publication Manual of the American Psychological Association (5th Edition)* as required by the Department of Psychology at Appalachian State University

I would like to thank my thesis chair, Joshua J. Broman-Fulks, for his continuous support and great sense of humor through this thesis process over the past two years. You have taught me a great deal about research over the past two years and without your advice and guidance along the way, I would not have had the knowledge or patience to complete a thesis. I would also like to thank my dedicated thesis committee, Dr. Michael and Dr. Curtin, and the undergraduate and graduate research assistants serving in our research lab (Laci, Kelsey, Carissa, Krystal, Lynsey-Paige, Laura, Erin, and Rebecca) whose encouragement helped me through my thesis process and without them I would not have been able to complete such a complex research study. Lastly, I would like to thank my amazing cohort members, Martha, Laura, Michael, Greg, Jessica, Jared, and Ina. Their encouragement and endless amounts of humor have made my graduate school experience much more than I had ever hoped for; I will miss you all dearly.

Effects of Aerobic Exercise on Carbon Dioxide Reactivity

among Individuals with High Anxiety Sensitivity

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Abstract

Anxiety sensitivity, or the fear of anxiety and anxiety-related sensations, is a risk factor for the development and maintenance of panic attacks and anxiety disorders. Aerobic exercise has been shown to be effective in reducing high anxiety sensitivity by exposing individuals to feared bodily sensations. Research has also demonstrated that an acute bout of aerobic exercise can reduce reactivity to CO₂ inhalation in both nonclinical samples and panic disorder participants. The present study examined the effects of acute aerobic exercise on reactivity to CO₂ inhalation among individuals with high anxiety sensitivity. Forty-five university students with high anxiety sensitivity (Anxiety Sensitivity Index-3 scores > 17) were randomly assigned to either 20 minutes of aerobic exercise or no exercise, after which they completed a 35% CO₂/ 65% O₂ inhalation task. Significant reductions in ASI-3 scores were reported after exercise/rest for both groups, though the groups did not significantly differ. Both groups also reported significantly greater panic symptoms after the CO₂ inhalation, though, again, no group differences emerged. Although brief aerobic exercise was not found to significantly reduce anxiety sensitivity or acute panic symptoms following CO₂ inhalation, implications of these results and potential directions for further research are discussed.

Keywords: Anxiety sensitivity, aerobic exercise, carbon dioxide inhalation

Effects of Aerobic Exercise on Carbon Dioxide Reactivity
among Individuals with High Anxiety Sensitivity

Anxiety sensitivity is the fear of anxiety and arousal sensations arising from the belief that these sensations can be harmful physically, psychologically, or socially (Reiss & McNally, 1985). Anxiety sensitivity is a significant risk factor for the development of panic among individuals who have no history of panic, the maintenance of panic disorder among untreated patients, and the re-occurrence of future panic attacks among patients who infrequently panic (Ehlers, 1995; Schmidt, Lerew, & Jackson, 1997, 1999). Although anxiety sensitivity is most closely associated with panic attacks, recent research indicates that anxiety sensitivity is also a significant predictor of a variety of Axis-I diagnoses (e.g. anxiety, mood, and alcohol use disorders; Schmidt, Zvolensky, & Maner, 2006).

Cognitive-behavioral therapy (CBT) is the most widely researched treatment for individuals with high anxiety sensitivity. In general, cognitive-behavioral therapy for panic consists of three primary components: psychoeducation, exposure to feared bodily sensations (interoceptive exposure), and cognitive restructuring. Studies consistently indicate that 10-12 sessions of CBT can significantly reduce self-reported anxiety sensitivity (e.g., McNally & Lorenz, 1987; Telch et al., 1993). Several studies suggest that even brief CBT (one to six sessions) can effectively reduce anxiety symptom fears (Gardenswartz & Craske, 2001; Kenardy, McCafferty, & Rosa, 2003; Schmidt et al., 2007).

Aerobic exercise interventions may be an effective alternative to cognitive-behavioral therapy for anxiety, panic, and other anxiety related disorders (Otto et al., 2007). Indeed, studies reveal that aerobic exercise is equally effective as cognitive therapy in reducing anxiety, and that the combination of exercise and cognitive therapy is no more effective in reducing anxiety than

exercise or cognitive therapy alone (Fremont & Craighead, 1987; McEntee & Halgin, 1999). In one study, Broocks et al. (1998) demonstrated that 10 weeks of aerobic exercise significantly improved symptoms of anxiety, depression, and panic among panic disorder patients. Furthermore, the effects of the exercise treatment were comparable to those demonstrated by participants who took clomipramine over a 10-week period. Thus, research indicates that aerobic exercise may be an effective treatment of anxiety and panic symptoms, generating effects comparable to those produced by traditional forms of CBT.

Research on the relation between anxiety sensitivity and exercise suggests that individuals with high anxiety sensitivity are significantly less likely to engage in a regular physical exercise regimen than their low anxiety sensitivity counterparts (McWilliams & Asmundson, 2001; Smits & Zvolensky, 2006). This has led some researchers to hypothesize that individuals with high levels of anxiety sensitivity may attempt to minimize physical activity in an attempt to avoid feared physiological arousal sensations (McWilliams & Asmundson, 2001). However, aerobic exercise has the potential to serve as an effective treatment for individuals with high anxiety sensitivity as it involves repeated, prolonged exposure to feared physical cues (interoceptive exposure). Indeed, recent research suggests that regular aerobic exercise can significantly reduce fears of anxiety-related physiological arousal among individuals with high anxiety sensitivity (Broman-Fulks, Berman, Rabian, & Webster, 2004; Broman-Fulks & Storey, 2008; Smits et al., 2008).

In the first study to investigate the effects of aerobic exercise on anxiety sensitivity, Broman-Fulks and colleagues (2004) randomly assigned individuals with high anxiety sensitivity (scores > 25 on Anxiety Sensitivity Index [ASI]) to complete a six-session regimen of high or low intensity aerobic exercise. Participants in the high-intensity exercise group walked or jogged

on a treadmill for 20 minutes at a pace that maintained their heart rates between 60 and 90% of their age-adjusted predicted maximal heart rate. Participants in the low-intensity exercise comparison group walked on a treadmill at a speed of one mile per hour. Exercise sessions were completed two to four times per week over a two week period, for a total of six sessions. Although the results of this study suggest that both high and low-intensity exercise can successfully decrease ASI scores (eta squared = 0.49), high-intensity exercise appears to be more beneficial than low-intensity exercise. Participants in the high-intensity exercise group reported significantly fewer fears of anxiety-related physiological sensations on the Body Sensations Questionnaire (eta squared = 0.15) and a significantly larger decrease in ASI scores from baseline to post-treatment than participants in the low-intensity exercise group (eta squared = 0.60).

In a second study, Broman-Fulks and Storey (2008) compared high-intensity aerobic exercise to no-exercise in a sample of 35 participants with high anxiety sensitivity (scores > 26 on the Anxiety Sensitivity Index-Revised [ASI-R]) who were not already involved in a regular aerobic exercise regimen. Participants in the high-intensity exercise condition completed six 20-minute sessions of aerobic exercise on a treadmill, whereas control participants reported to the lab on six occasions only to complete questionnaires. Results indicated that exercise participants reported substantially lower ASI-R at post and one week follow-up in comparison with their baseline scores (partial eta squared = 0.49) and scores for individuals in the no-exercise control condition, whose scores did not significantly change from baseline (partial eta squared = 0.13). Notably, anxiety sensitivity scores significantly declined following completion of the first exercise session and remained relatively stable through the remaining sessions (partial eta squared = 0.18). Thus, aerobic exercise appears to have an immediate effect on anxiety-related

fears and that additional exercise sessions serve to maintain the anxiolytic effects of exercise.

In a third study, Smits et al. (2008) attempted to expand upon previous research by evaluating whether adding a cognitive restructuring component to aerobic exercise would increase the effectiveness of exercise as a treatment for high anxiety sensitivity. Specifically, participants with high anxiety sensitivity (scores > 25 on the ASI) were randomly assigned to complete six 20-minute exercise sessions either with or without cognitive restructuring. Participants in the cognitive restructuring group were informed that by repeatedly being exposed to feared physical sensations, participants would gain evidence to support the notion that the predicted outcome is likely to not occur (e.g. arousal sensations such as dizziness produced by exposure exercise will likely not lead to feared outcome of fainting). Results indicated that participants who received both aerobic exercise and cognitive restructuring experienced a reduction in anxiety sensitivity levels, though the reduction was not significantly different from participants who did not receive cognitive restructuring. Thus, this study suggests that adding cognitive restructuring to aerobic exercise does not provide added benefit for reducing anxiety sensitivity beyond exposure to feared physiological sensations.

Although researchers have traditionally assessed anxiety sensitivity via self-report questionnaires (e.g., ASI), some researchers have proposed to assess anxiety-related fears by evaluating participant responses to challenge tasks, which are activities that induce feared physiological sensations. For example, several studies have examined anxious responding to carbon dioxide (CO₂) inhalation challenge tasks among panic disorder patients (Beck, Shipherd, & Zebb, 1996; Perna, Romano, Caldirola, Cucchi, & Bellodi, 2003). One study by Perna and colleagues (2003) found that 62 % of panic patients experienced a panic attack after inhaling a 35% CO₂/ 65% O₂ mixture. In addition, anxiety sensitivity scores (ASI) were found to

significantly predict somatic symptom reactions to the CO₂ inhalation task. In a separate study, Beck and colleagues (1996) found that participants with high anxiety sensitivity reported significantly higher overall subjective anxiety and experienced faster heart rates when completing a CO₂ biological challenge task (35% CO₂/65% O₂) compared to participants with low anxiety sensitivity. Thus, research suggests that individuals with high anxiety sensitivity respond more anxiously to the physiological arousal sensations produced by inhalation tasks than individuals low in anxiety sensitivity.

Some research using inhalation tasks has found that reactivity to CO₂ challenge tasks appears to decrease with repeated exposure to anxiety-related symptoms using CBT or other methods of exposure. In one study, Schmidt, Trakowski, and Staab (1997) demonstrated that participants assigned to CBT for panic experienced a significant decline in ASI scores from baseline to post and responded with fewer panic symptoms after inhaling a mixture of 35% CO₂/65% O₂ compared to participants in the waitlist control condition.

Aerobic exercise appears to be an effective exposure technique to reduce anxiety sensitivity using self-report measures (e.g. ASI; ASI-R). However, little research has studied the effects of aerobic exercise on the reactivity to CO₂ inhalation tasks, which may provide a more objective way to assess anxiety sensitivity than self-report measures. Results to date appear to suggest that nonclinical participants who exercise before completing a CO₂ inhalation procedure respond less anxiously to CO₂ challenge than those who do not exercise (Esquivel, Schruers, Kuipers, & Griez, 2002; Smits, Meuret, Zvolensky, Rosenfield, & Seidel, 2009). In one study, participants were randomly assigned to complete an exertion (bicycle) or no-exertion protocol followed by a single inhalation of 35% CO₂/65% O₂ mixture (Esquivel et al., 2002). Results indicated that participants who completed the exertion condition reported significantly fewer

panic symptoms measured by the Diagnostic and Statistical Manual-IV-Text Revision (American Psychiatric Association [*DSM-IV-TR*], 2000) Panic Symptom List after the CO₂ challenge compared to participants in the no-exertion condition. In a recent study, Smits et al. (2009) examined the effects of acute aerobic exercise (running) on reactivity to CO₂ inhalation. Participants who denied any history of panic were randomly assigned to either a 20-minute aerobic exercise condition or a no exercise condition. All participants completed a biological challenge task consisting of a single inhalation of a 35% CO₂/65% O₂ mixture after either exercise or rest. Results showed that one 20-minute session of aerobic exercise significantly reduced anxious responding to CO₂ challenge compared to no exercise.

Another recent study by Esquivel et al. (2008) examined the effects of aerobic exercise on reactivity to a CO₂ inhalation task using a clinical sample of patients with panic disorder. Participants were assigned to either a moderate/hard exercise treatment group or a light exercise/control group. Participants in the moderate/hard exercise group completed a single 15-minute session of aerobic exercise on a bicycle while maintaining heart rates between 80 and 90% of their maximal heart rates. Participants in the control group engaged in minimal exercise, which did not generate the significant increases in heart rates as compared intense exercise. All participants completed an inhalation task following aerobic exercise using a mixture of 35% CO₂ and 65% O₂. Results indicated that participants in the moderate/hard exercise group reported significantly fewer panic symptoms in response to the CO₂ challenge task compared to the light exercise comparison group.

Although research appears to indicate that participation in aerobic exercise reduces reactivity to CO₂ challenge tasks among healthy participants and participants with panic disorder, researchers have yet to examine the effects of aerobic exercise on CO₂ reactivity among

individuals with high anxiety sensitivity. Thus, the purpose of the present study was to address this gap in the literature. Based on research demonstrating significant reductions in anxiety sensitivity following participation in aerobic exercise (e.g. Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008; Smits et al., 2008) and reduced CO₂ reactivity among nonclinical and panic disorder participants following exercise (e.g. Esquivel et al., 2002; Esquivel et al., 2008; Smits et al., 2009), it is hypothesized that:

- (1) All participants will report a reduction in anxiety sensitivity from pre-exercise/rest to post-exercise/rest; however, participants who complete a single session of aerobic exercise will report a more significant reduction in anxiety sensitivity from pre-exercise/rest to post-exercise/rest when compared to participants in a no-exercise control condition,
- (2) All participants will report an increase in acute panic symptoms from pre-exercise/rest to post inhalation; however, participants who complete a single session of aerobic exercise will report significantly fewer acute panic symptoms from pre-exercise/rest to post inhalation when compared to participants in a no-exercise control condition.

Method

Participants

Participants ($n = 45$) were 28 female and 17 male undergraduate psychology students at Appalachian State University who received course credit for completing the study.

Approximately 710 students were screened and only those who: (1) achieved a score of 17 or higher on the ASI-3 ($> .5$ standard deviations above the mean), (2) were in good physical health, and (3) were not currently involved in an aerobic exercise program were recruited to participate

in this study. Current involvement in exercise was operationally defined as having exercised more than two times over the past two weeks. The Physical Activity Readiness Questionnaire was administered to participants to ensure they were physically healthy enough to engage in exercise. No one was excluded from this study based on gender, race, or any other demographic characteristic. After conducting an a priori power analysis using an alpha value of .05 with 80% power, a sample size of 34 participants would be needed to detect a medium effect size ($f = .25$). This study's procedures were reviewed and approved by the Institutional Review Board on October 14, 2009 (see Appendix A).

Measures

Anxiety Sensitivity Index – 3 (ASI-3; Taylor et al., 2007). The ASI-3 consists of 18-items and was designed to comprehensively assess anxiety sensitivity via a general anxiety sensitivity factor and three lower-order factors: physical, cognitive, and social concerns. Participants rate items on a 5-point Likert scale (0= *very little* to 4= *very much*) the extent to which they find anxiety symptoms distressing. Sample items include: “It scares me when my heart beats rapidly” and “I worry that other people will notice my anxiety.” The original 16-item version of the ASI which was not intended to be multidimensional was found to have factor loading problems during replication studies and thus the stability of the ASI was questionable. The ASI-R was then created which was found to be more reliable and stable than the ASI but with 36-items, the ASI-R was determined to be very lengthy. The ASI-3 was created to address limitations identified in previous versions, and initial research suggests it has high reliability (ASI total: $\rho = .90$; Osman et al., 2010; Taylor et al., 2007). In a study comparing the ASI-3 to the original version which contained 16 items, the ASI-3 was found to have less error variance and higher subscale and total scale validity for a wide range of sample characteristics (i.e. gender,

race, diagnosis) compared to the ASI (Taylor et al., 2007).

Acute Panic Inventory (API; Liebowitz, Gorman, Fyer, Dillon, & Klein, 1984). The API consists of 17 items which examines the presence of panic symptoms. Participants rate the degree to which specific panic symptoms are experienced using a 4-point Likert scale (0= *not present* to 3= *severe*). Sample items include: “Are you sweating?” and “Do you feel faint?” The API also includes subjective units of distress (SUDS) ratings of anxiety (0= *not distressed at all* to 100= *worst imaginable experience*) to determine the degree to which the symptoms being experienced is distressing for the individual.

Physical Activity Readiness Questionnaire (PAR-Q). The PAR-Q functions as a screening test for prospective participants who are interested in beginning or increasing the intensity of an exercise program. The PAR-Q consists of seven questions that are designed to identify individuals who require a medical examination prior to beginning or intensifying an exercise program. Each item is answered on a yes-no scale. If any question is answered “yes,” a medical examination by a physician is recommended before participation in the exercise program. The specificity of the PAR-Q has been estimated to be approximately 81% (Shephard, Cox, & Simper, 1981), and the sensitivity of the PAR-Q over the past two decades has been 100%, with more than one million people having completed the measure and no reports of serious cardiovascular complications among those who subsequently participated in exercise (Cardinal, Esters, & Cardinal, 1996). Based on results from the PAR-Q, all aerobic exercise participants in the present study were able to complete the 20-minute aerobic exercise session and thus, no one was excluded from the study due to medical problems.

Physical Activity Rating (PA-R). The PA-R consists of three questions which are used to determine overall level of physical activity and perceived functional ability. Item one is

answered on a scale from 0 (inactive) to 10 (vigorous activity) to determine the participant's overall activity level in the past six months. Items two and three assess the participants perceived abilities for walking on a track for one mile and how fast they could cover a three mile distance from 0 (walking at a slow pace) to 13 (running at a fast pace). The PA-R was used to determine initial treadmill speed due to the lack of physical exercise among the specific sample used in this study.

Heart Rate. A Polar heart rate strap was worn by all participants for the entire session and heart rates were monitored from a wrist watch at baseline, throughout the exercise or rest procedures (i.e. 2, 5, 10, 15, 20 minutes), and immediately following the inhalation task. Procedures for examining heart rates followed protocols from previous aerobic exercise studies as well as studies using CO₂ inhalation tasks (Broman-Fulks & Storey, 2008). Recommended aerobic exercise heart rates based on age were obtained from the American College of Sports Medicine (ACSM; 2000).

Procedures

Prospective participants were initially screened in classroom settings at Appalachian State University. During the screening session, potential participants completed a screening informed consent form (see Appendix B), a demographic questionnaire (see Appendix C), and the ASI-3. Participants who met inclusion criteria were invited to participate in the study by email or by telephone. Those who agreed to participate were scheduled for a laboratory session, assigned a participant identification number, and randomly assigned to either the exercise or no-exercise condition using their identification number (e.g., odd numbers corresponded to exercise condition assignment). Upon reporting to the lab for their initial session, participants completed the informed consent process (see Appendix D for Exercise Group Informed Consent and

Appendix E for Non-Exercise Group Informed Consent) and any questions that participants had about the session were answered at this time by a research assistant.

After completing the informed consent process, participant's height, weight, and current age were obtained. Participants were fitted with a heart monitor chest strap that would be worn throughout the rest of the session. Participants then completed a series of computerized questionnaires using SurveyMonkey which included the ASI-3 and API. While the participant completed the questionnaires, he/she was instructed to remain seated for five minutes to obtain a base line heart rate measure.

Exercise Condition. Participants randomly assigned to the aerobic exercise group completed the PAR-Q and PA-R to determine their perceived level of fitness. Following exercise protocols from previous anxiety sensitivity studies, the participants age, gender, height, and weight were entered into an excel spreadsheet to calculate BMI ($(\text{weight}/2.2) / (\text{height} \times 0.0254)^2$) and their scores on the PA-R were entered into an excel spreadsheet to determine the VO₂max ($44.895 + (7.042 \times [0 \text{ if female, } 1 \text{ if male}]) - (0.823 \times \text{BMI}) + (0.738 \times \text{PA-R}) + (0.688 \times \text{PFA})$) and recommended treadmill starting speed: $(([\text{VO}_2\text{max} \times 0.7] - 3.5) / 0.29) / 26.82$ (Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008). The participant's heart rate was then calculated based on the participant's current age. The following formula was used as recommended by the ACSM (2000) to determine the lower and upper bounds of each individual's aerobic heart rate range: $(220 - \text{age}) \times (0.65 [\text{lower-bound}] \text{ or } 0.75 [\text{upper-bound}])$. Participants in the exercise group then completed a directed stretching procedure that consisted of toe touch (15 seconds), side toe touch (15 seconds per side), quad stretch (15 seconds per leg), seated side to touch (15 seconds per leg), and lower back stretch (15 seconds).

After stretching, participants were instructed to walk slowly for two minutes to warm-up

on the treadmill. Warm-up treadmill speed was either two mph or one mph lower than the determined starting treadmill speed, depending on which was lower. Participants were instructed not to adjust the controls on the treadmill and that a laboratory assistant would adjust the treadmill speed periodically. Participants were told that each time the examiner adjusted the treadmill speed, their heart rate would be recorded, and they would be asked to rate their perceived exertion (RPE) on a scale from 1 (extremely easy) to 10 (extremely hard).

Following the warm-up period, participants began the 20-minute aerobic exercise procedure and a laboratory assistant increased the treadmill speed to a level pre-determined using their PA-R scores and BMI. Participant heart rates were recorded at regular intervals during exercise (i.e., 2, 5, 10, 15, and 20 minutes), and treadmill speed was adjusted to keep the participant's heart rate between 65 and 75% of their age-adjusted predicted maximal heart rate. Examiners only had contact with the participant during the exercise protocol when checking his/her heart rate, adjusting treadmill speed, and requesting the participant's RPE. Following completion of the exercise protocol, participants completed a two-minute cool down period by walking at a pace of 2 mph on the treadmill.

No-Exercise Condition. Participants in the no-exercise condition were asked to sit quietly in a chair for 20 minutes. Participants were reminded not to use cell phones during the session and had their heart rates monitored at intervals equivalent to the exercise condition (i.e., 2, 5, 10, 15, and 20 minutes) to ensure that they had an equal amount of contact with the examiner as participants in the exercise group.

Following completion of the exercise or rest session, participants were administered the ASI-3 and API a second time. Participants were then administered a CO₂ inhalation task in which they inhaled a single vital capacity breath of a 35% CO₂/ 65% oxygen mixture. All

participants were seated during this procedure as a safety precaution. Prior to completing the inhalation task, participants were given the following instructions:

In a few moments, you will take a single vital capacity breath of a mixture containing 35% carbon dioxide and 65% oxygen. The goal is to take in as much air as possible. Therefore, you will need to exhale completely, and then take a full and complete inhalation using the mouth piece that is attached to the bag. Please hold the inhalation for five seconds. I will count to five for you and then you can exhale (Schmidt, 1999; Smits et al., 2009).

Participants were then instructed to inhale a complete breath and then exhale into the mouth piece of a Spirometer to measure the amount of air that the participant could fit in his/her lungs. Next, the examiner demonstrated vital capacity breathing in which the examiner exhaled completely, inhaled a complete breath and held it for five seconds before exhaling. The participant was asked to practice this procedure using a mouthpiece that would later be connected to the equipment containing the CO₂ mixture. Following the vital capacity breathing practice, participants were fitted with a nose clip and asked to exhale fully before inhaling one full breath of the CO₂/oxygen mixture from a 4.8 liter Venti-comp bag filled to capacity. Participants were asked to hold that breath for five seconds as the experimenter counted out loud, after which the examiner instructed them to exhale. Heart rates were monitored during the inhalation task and recorded immediately following exhalation. Twenty seconds following exhalation, participants completed a paper form of the API while remaining seated. Participants then rested quietly until any lingering anxiety symptoms subsided.

Upon completion of the inhalation task, participants completed a third series of questionnaires, including the ASI-3, via SurveyMonkey. Participants were then instructed to take

off the heart rate strap, and they were dismissed. Participants received their credit slips and referral information for health services (see Appendix F) and were invited back to the laboratory for a short debriefing session after all participants had completed the study. The debriefing session consisted of explaining the real purpose and potential benefits of the study to participants, and any questions that participants had were answered at this time (see Appendix G).

Results

Preliminary Analyses

Independent samples t-tests and chi-square analyses indicated that the exercise and no-exercise groups were comparable at baseline on all demographic variables (all $ps > .10$). Independent samples t-tests indicated that baseline ASI-3 and API scores were not significantly different between the two groups (Table 1). Pearson-product moment correlations were conducted to assess if anxiety measures were related at baseline and following exercise/rest. A strong correlation was found between baseline ASI-3 and API scores ($r = .55, p < .01$).

Manipulation Check: aerobic exercise

Based on the recommended heart rate intensity range for aerobic exercise from the ACSM (2000), participants in the exercise condition had average heart rate intensities at all time points that were within the age-appropriate range of 131–151 beats per minute. As expected, an independent samples t-test indicated that the mean heart rates for participants in the no-exercise condition were significantly lower than the average heart rates for the aerobic exercise condition at all time points (2, 5, 10, 15, 20 minutes; Table 2).

Anxiety Sensitivity Analyses

A 2 x 2 (group x time) mixed-model analysis of variance (ANOVA) was computed to test the effects of aerobic exercise on anxiety sensitivity. Results showed a significant main effect for time, $F(1, 45) = 7.72, p = .008, \eta_p^2 = .15$, with ASI-3 scores decreasing from pre-exercise/rest ($M = 36.56, SD = 10.28$) to post-exercise/rest ($M = 34.29, SD = 10.77$). However, results indicated that there was not a significant main effect for group, $F(1, 45) = .14, p = .71, \eta_p^2 = .00$, and the group by time interaction effect failed to reach significance, $F(1, 45) = .42, p = .52, \eta_p^2 = .01$ (Figure 1).

To investigate changes in ASI-3 scores from pre-exercise/rest to post-exercise/rest for each group, post hoc within subjects ANOVAs were computed. Results of analyses within the exercise group revealed that the effect for time approached significance, $F(1, 23) = 3.99, p = .06, \eta_p^2 = .15$, with ASI scores decreasing from pre ($M = 36.26, SD = 10.50$) to post ($M = 33.48, SD = 11.34$). For the rest group, a significant effect for time was found, $F(1, 22) = 4.68, p = .04, \eta_p^2 = .18$, with ASI scores decreasing from pre ($M = 36.86, SD = 10.29$) to post ($M = 35.14, SD = 10.35$).

Consistent with previous research, the clinical significance of the effects of aerobic exercise on anxiety sensitivity was investigated by examining the number of participants in each group that exhibited a decrease in ASI-3 scores of one standard deviation (10 points) or more (e.g., Broman-Fulks et al., 2004). Results indicated that only 3 of 23 (13 %) aerobic exercise participants and 2 of 22 (9%) rest participants demonstrated a clinically significant change in ASI-3 scores from pre-exercise/rest to post-exercise/rest. Chi square analyses indicated that there was not a statistically significant difference in treatment responders between the two groups, $\chi^2(1, N = 45) = .178, p = .67$.

Acute Panic Analyses

A 2 x 2 (group x time) mixed-model ANOVA was computed to test the effects of aerobic exercise on acute panic symptoms. Results revealed a significant main effect for time, $F(1, 42) = 19.91, p = .001, \eta_p^2 = .332$, with API scores increasing from pre-exercise/rest ($M = 22.67, SD = 5.42$) to post-inhalation ($M = 27.36, SD = 7.21$). Results showed that the main effect for group, $F(1, 42) = 1.15, p = .29, \eta_p^2 = .03$, and the group by time interaction failed to reach significance, $F(1, 42) = .27, p = .61, \eta_p^2 = .01$ (Figure 2).

To investigate changes in API scores from pre-exercise/rest to post-exercise/rest for each group, post hoc ANOVAs were computed. For the exercise group, a significant effect for time was found, $F(1, 21) = 6.85, p = .02, \eta_p^2 = .26$, with API scores increasing from pre ($M = 22.05, SD = 5.79$) to post ($M = 26.19, SD = 5.95$). For the rest group, a significant effect for time was found, $F(1, 21) = 14.34, p = .001, \eta_p^2 = .42$, with API scores increasing from pre ($M = 23.29, SD = 5.08$) to post ($M = 28.52, SD = 8.26$).

Discussion

Previous research has suggested that aerobic exercise is a cost efficient and effective treatment for anxiety and panic symptoms (Broman-Fulks & Storey, 2008; Otto et al., 2007). By exposing people to anxiety-related physical sensations, previous research has suggested that aerobic exercise generates comparable effects to other anxiety treatments, such as CBT, at reducing anxiety sensitivity (Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008; Smits et al., 2008). Similar to previous research, the results of the present study indicated that individuals who participated in a single session of aerobic exercise reported a significant decrease in ASI-3 scores from pre-exercise to post-exercise. However, in contrast to previous research, the control (i.e., rest) condition reported a comparable reduction in ASI-3 scores to those reported by

participants in the exercise condition. Similarly, individuals in both aerobic exercise and rest conditions reported comparable increases in API scores from baseline to post-CO₂ inhalation.

When investigating aerobic exercise as an intervention for high anxiety sensitivity, previous studies have found a significant reduction in ASI scores for aerobic exercise participants following a single session of exercise; however, significant reductions in ASI scores following a single session have also been reported by control participants, making it difficult to discern the effects of acute aerobic exercise for individuals with high anxiety sensitivity (Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008). For example, in a study by Broman-Fulks and Storey (2008), participants in both the intervention and control conditions (i.e. aerobic exercise and no exercise) reported a decline in ASI-R scores after the initial session (ASI-R-exercise: pre-post decrease of 14.42 points; control: pre-post decrease of 6.67 points). However, after six sessions, participants in the aerobic exercise condition reported significantly lower ASI-R scores than controls whose ASI-R scores regressed towards the mean by session six (ASI-R-exercise: pre-post decrease of 17.25 points; control: pre-post decrease of -1.50 points). Although the present study only investigated the effects of one session of aerobic exercise on reducing anxiety sensitivity, findings that both aerobic exercise and control groups report significant reductions in ASI-3 scores following one session suggest that, like previous studies, multiple sessions of aerobic exercise may be required before treatment effects are detectable due to initial declines in scores among control conditions.

Although anxiety sensitivity is conceptualized as a relatively stable individual difference variable, accumulating evidence indicates that the mere repeated completion of anxiety sensitivity measures is associated with significant reductions in self-reported anxiety sensitivity, even among ostensible control groups (e.g., Broman-Fulks, Berman, Martin, Marsic, & Harris,

2009; Marsic, Broman-Fulks, & Berman, in press). Indeed, a number of anxiety sensitivity studies attempting to evaluate the efficacy of various treatments have found that participants in both the treatment and control conditions report significant reductions in ASI scores from pre- to post-treatment (Kenardy et al., 2003; Schmidt et al., 2007; Watt, Stewart, Lafaire, & Uman, 2006). For example, Kenardy et al. (2003) found that after a six-week CBT intervention for high anxiety sensitivity delivered via the internet, participants in both the treatment and control groups reported decreases in ASI scores (AS-intervention: pre-post decrease of 9.68 points; control: pre-post decrease of 5.50 points). Similarly, Schmidt et al. (2007) investigated a brief amelioration intervention for high anxiety sensitivity and found that participants in both the intervention and control groups reported decreases in ASI scores following the intervention (ASI-intervention: pre-post decrease of 5.1 points; control: pre-post decrease of 2.9 points). Thus, the significant decline in ASI scores among the rest condition in the present study may represent another case of the well-documented temporal instability of ASI scores, and further highlight the concerns about using anxiety sensitivity measures in prospective research.

Several studies have investigated possible explanations (i.e. regression to the mean; practice effects) for the decline in ASI scores following initial assessment (Broman-Fulks et al., 2009; Marsic et al., in press). For example, Marsic et al. (in press) examined whether the number of administrations of the ASI-R during a given time period or the amount of time between the initial assessment and subsequent assessments were related to the initial decrease in ASI scores. Results indicated that the decline in ASI-R scores occurred only from the first to second administration and scores remained relatively stable for subsequent administrations of the ASI-R. Results also revealed that regardless of the time between administration one and two (i.e. one day; 2 weeks), the decrease in ASI-R scores was still present. Additionally, test-retest

correlations (i.e. reliability) were found to be greater for assessment times 2 and 3 when compared to assessment times 1 and 2 (Marsic et al., in press). In a second study by Broman-Fulks et al. (2009), possible explanations for the decline in ASI scores even for control groups were examined (e.g. regression to the mean or exposure to anxiety related information via self-report measures or psychiatric interviews). Participants either received a diagnostic interview related to anxiety symptoms, a diagnostic interview related to anxiety symptoms plus education on physiological responses to stress, a diagnostic interview related to psychotic symptoms, or no interview. Results indicated that regardless of condition or level of anxiety sensitivity, decreases in ASI-R scores were reported from baseline to post and exposure to psychiatric information did not affect the decrease in ASI-R scores (Broman-Fulks et al., 2009). Conclusions from previous anxiety sensitivity studies suggest that the decline in ASI scores following initial assessment even for control groups can not be explained by exposure to anxiety related symptoms or regression to the mean. Additionally, multiple administrations of anxiety sensitivity measure have been found to maximize reliability and limit potential dose-response effects. Future researchers may wish to include multiple baseline measurements of anxiety sensitivity to help control for the decline in anxiety sensitivity scores following initial assessment.

It was also predicted that participation in aerobic exercise would temper anxious responding to a CO₂ inhalation task compared to controls. However, this hypothesis was only partially supported, with both aerobic exercise and control participants reporting significant increases in API scores following inhalation of the CO₂ mixture. However, the groups did not significantly differ in API scores post-inhalation. Some studies investigating the effects of aerobic exercise on CO₂ responding have found that healthy and panic disorder participants engaging in brief aerobic exercise report significantly fewer panic symptoms after a CO₂

inhalation than controls (Esquivel et al., 2002; Esquivel et al., 2008; Smits et al., 2009); however, other research suggests that brief exposure to physiological arousal via 20 minutes of aerobic exercise significantly increases API scores (i.e., panic symptoms) and somatic complaints for participants with panic disorder compared to healthy controls (Strohle et al., 2009). The present study failed to provide evidence that individuals with high anxiety sensitivity who engage in brief aerobic exercise respond with significantly fewer panic symptoms following CO₂ inhalation compared to controls.

To date, research investigating CO₂ reactivity following aerobic exercise for individuals with high anxiety sensitivity is limited. Based on results from previous CO₂ reactivity studies and the present study, it appears that repeated CO₂ inhalation which increases exposure to feared arousal sensations may be needed to detect group differences in anxiety and panic symptoms between aerobic exercise and control conditions (Beck & Wolf, 2001; Schmidt et al., 1997). For example, in a replication study by Beck and Wolf (2001), repeated inhalation of a CO₂ mixture was shown to significantly reduce anxiety ratings for 67 % of individuals with high anxiety sensitivity from post-inhalation one to post-inhalation 15 (decrease of approximately 20 points); however, high anxiety sensitivity participants in this study reported a significant increase in anxiety ratings from baseline to post inhalation 1 (increase of approximately 40 points). Thus, it appears that although some research suggests a single exposure to feared bodily sensations can lead to positive treatment outcomes, repeated exposure to bodily sensations via CO₂ inhalation has been found to be more effective at generating reductions in anxiety ratings for individuals with high anxiety sensitivity compared brief exposure.

Further research will be necessary to clarify several key questions. For example, the stability of current measures of anxiety sensitivity in prospective research is questionable.

Research uncovering the source of the temporal instability of anxiety sensitivity scores or developing measures that are less susceptible to declining anxiety sensitivity scores among ostensible control groups would benefit the field. In the interim, future research would benefit from using multiple measures of anxiety sensitivity to control for decreases following a single session. Future research may also wish to investigate whether other forms of exercise (e.g. weightlifting, yoga) could be effect alternative treatments for individuals with high anxiety sensitivity. Additionally, exercise interventions should be compared to typical interventions for high anxiety sensitivity (e.g. CBT) to determine if aerobic exercise is as effective in reducing anxiety sensitivity as typical treatments.

Although the present study was intended to clarify some of the concerns acknowledged by previous aerobic exercise and anxiety sensitivity studies, there were several limitations of this study which may have contributed to the non-significant results. First, with respect to demographic characteristics (e.g., age, race, ethnicity), the sample was relatively homogeneous, raising concerns about the generalizability of the present findings. In addition, the use of a selected sample (high anxiety sensitivity; non-exercisers), raises further questions about the external validity of the results of this study to clinical samples (e.g. panic disorder, anxiety disorders).

Second, detected effects (e.g. partial eta squared) for both ASI-3 and API scores were much smaller than anticipated. Specifically, effect sizes for ASI and API main and interaction investigations in the present study were small (ASI: $\eta_p^2 = .01$ to $.03$; API: $\eta_p^2 = .01$ to $.03$) compared to partial eta squared measurements of $.16$ to $.49$ reported in previous studies (Broman-Fulks & Storey, 2008; Smits et al., 2009). An effect size of at least $.05$ was needed based on the present studies sample size of 45 to detect a moderate effect 80 % of the time an

effect occurred. Thus, a larger sample may have provided an increased chance of having significant results. However, due to limiting participation in this study to individuals with high anxiety sensitivity who were non-exercisers, over 700 individuals had to be screened in order to obtain the current sample. Specifically, of the individuals screened for this study, approximately six percent met inclusion criteria. Thus, over 3000 individuals would need to be screened in order to obtain a large enough sample ($n = 198$) to detect a small effect ($\eta_p^2 = .01$).

Although there were several weaknesses of the present study which may have affected the results, this study also had several important strengths. For example, the study utilized a randomized controlled design, thereby minimizing threats to internal validity. In addition, participants were blind to treatment conditions and unaware there was an alternative treatment (aerobic exercise or rest) which further reduced the chance of error within this study.

Furthermore, participants completed only one session of aerobic exercise followed by an inhalation procedure and were not asked to return to the laboratory for multiple sessions eliminating the risk of drop out and therefore maximizing the retention rate. Similarly, because participants were studied for a single session, costs were relatively low.

In conclusion, one session of aerobic exercise does not appear to significantly reduce anxiety sensitivity or acute panic symptoms after a CO₂ inhalation for individuals with high anxiety sensitivity. Further research is needed to better understand the effects of aerobic exercise on high anxiety sensitivity and determine whether aerobic exercise is beneficial in reducing panic symptoms after induction of physical arousal via CO₂ inhalation. Future investigations that address some of the limitations of the current study (i.e. larger sample size, diverse sample characteristics) and previous studies will help reveal whether aerobic exercise should be considered an effective treatment option for high anxiety sensitivity individuals.

References

- American College of Sports Medicine (2000). *ACSM's guidelines for exercise testing and prescription* (6th ed.). Baltimore: Lippincott Williams and Wilkins.
- American Psychiatric Association (2000). *Diagnostic and Statistical Manual and Mental Disorders* (4th ed., text revision). Washington, DC: Author.
- Beck, J. G., Shipherd, J. C., & Zebb, B. J. (1996). Fearful responding to repeated CO₂ inhalation: A preliminary investigation. *Behaviour Research and Therapy*, 34, 609-620.
- Beck, J. G., & Wolf, M. S. (2001). Response to repeated CO₂ in individuals with elevated anxiety sensitivity: Replication with 20 % CO₂. *Journal of Behavioral Therapy and Experimental Psychiatry*, 32, 1-16.
- Broman-Fulks, J. J., Berman, M. E., Martin, H. M., Marsic, A., & Harris, J. A. (2009). Phenomenon of declining anxiety sensitivity scores: A controlled investigation. *Depression and Anxiety*, 26, e1-e9.
- Broman-Fulks, J. J., Berman, M. E., Rabian, B., & Webster, M J. (2004). Effects of aerobic exercise on anxiety sensitivity. *Behaviour Research and Therapy*, 42, 125-136.
- Broman-Fulks, J. J., & Storey, K. M. (2008). Evaluation of a brief aerobic exercise intervention for high anxiety sensitivity. *Anxiety, Stress, & Coping*, 17, 17-28.
- Broocks, A., Bandelow, B., Pekrun, G., George, A., Meyer, T., Bartmann, U.,... Ruther, E. (1998). Comparison of aerobic exercise, clomipramine, and placebo in the treatment of panic disorder. *American Journal of Psychiatry*, 155, 603-609.
- Cardinal, B. J., Esters, J., & Cardinal, M. K. (1996). Evaluation of the revised physical activity readiness questionnaire in older adults. *Medicine & Science in Sports & Exercise*, 28, 468-472.

- Ehlers, A. (1995). A one-year prospective study of panic attacks: Clinical course and factors associated with maintenance. *Journal of Abnormal Psychology, 104*, 164-172.
- Esquivel, G., Diaz-Galvis, J., Schruers, K., Berlanga, C., Lara-Munoz, C., & Griez, E. (2008). Acute exercise reduces the effects of a 35 % CO₂ challenge in patients with panic disorder. *Journal of Affective Disorders, 107*, 217-220.
- Esquivel, G., Schruers, K., Kuipers, H., & Griez, E. (2002). The effects of acute exercise and high lactate levels on 35 % CO₂ challenge in healthy volunteers. *Acta Psychiatrica Scandinavica, 106*, 394-397.
- Fremont, J., & Craighead, L. W. (1987). Aerobic exercise and cognitive therapy in the treatment of dysphoric disorders. *Cognitive Therapy and Research, 11*, 241-251.
- Gardenswartz, C. A., & Craske, M. G. (2001). Prevention of panic disorder. *Behavior Therapy, 32*, 725-737.
- Kenardy, J., McCafferty, K., & Rosa, V. (2003). Internet-delivered indicated prevention for anxiety disorders: a randomized controlled trial. *Behavioural and Cognitive Psychotherapy, 31*, 279-289.
- Liebowitz, M. R., Gorman, J. M., Fyer, A. J., Dillon, D. J., & Klein, D. F. (1984). Effects of naloxone on patients with panic attacks. *American Journal of Psychiatry, 141*, 995-997.
- Marsic, A., Broman-Fulks, J. J., & Berman, M. E. (In Press). The effects of measurement frequency and timing on anxiety sensitivity scores. *Cognitive Therapy Research*.
- McEntee, D. J., & Halgin, R. P. (1999). Cognitive group therapy and aerobic exercise in the treatment of anxiety. *Journal of College Student Psychotherapy, 13*, 37-55.
- McNally, R. J., & Lorenz, M. (1987). Anxiety sensitivity in agoraphobics. *Journal of Behavior Therapy and Experimental Psychiatry, 18*, 3-11.

- McWilliams, L. A., & Asmundson, G. J. (2001). Is there a negative association between anxiety sensitivity index scores in patients with major depression: correlates and changes with antidepressant treatment. *Journal of Anxiety Disorders, 9*, 117-123.
- Osman, A., Gutierrez, P. M., Smith, K., Fang, Q., Lozano, G., & Devine, A. (2010). The anxiety sensitivity index-3: Analyses of dimensions, reliability estimates, and correlations in nonclinical samples. *Journal of Personality Assessments, 92*, 45-52.
- Otto, M. W., Church, T. S., Craft, L. L., Greer, T. L., Smits, J. A., & Trivedi, M. H. (2007). Exercise for mood and anxiety disorders. *Journal of Clinical Psychiatry, 68*, 669-676.
- Perna, G., Romano, P., Caldirola, D., Cucchi, M., & Bellodi, L. (2003). Anxiety sensitivity and 35 % CO₂ reactivity in patients with panic disorder. *Journal of Psychosomatic Research, 54*, 573-577.
- Reiss, S., & McNally, R. (1985). Expectancy model of fear. In S. Reiss and R.R. Bootzin (Eds.) *Theoretical Issues in Behavior Therapy*. New York: Academic Press.
- Schmidt, N. B. (1999). Examination of differential anxiety sensitivities in panic disorder: A test of anxiety sensitivity subdomains predicting fearful responding to a 35 % CO₂ challenge. *Cognitive Therapy and Research, 23*, 3-19.
- Schmidt, N. B., Eggleston, A. M., Woolaway-Bickel, K., Fitzpatrick, K. K., Vasey, M. W., & Richey, J. A. (2007). Anxiety Sensitivity Amelioration Training (ASAT): A longitudinal primary prevention program targeting cognitive vulnerability. *Journal of Anxiety Disorders, 21*, 302-319.
- Schmidt, N. B., Lerew, D. R., & Jackson, R. J. (1997). The role of anxiety sensitivity in the pathogenesis of panic: Prospective evaluation of spontaneous panic attacks during acute stress. *Journal of Abnormal Psychology, 106*, 355-364.

- Schmidt, N. B., Lerew, D. R., & Jackson, R. J. (1999). Prospective evaluation of anxiety sensitivity in the pathogenesis of panic: Replication and extension. *Journal of Abnormal Psychology, 108*, 532-537.
- Schmidt, N. B., Trakowski, J. H., & Staab, J. P. (1997). Extinction of panicogenic effects of a 35 % CO₂ challenge in patients with panic disorder. *Journal of Abnormal Psychology, 106*, 630-638.
- Schmidt, N. B., Zvolensky, M. J., & Maner, J. K. (2006). Anxiety sensitivity: Prospective prediction of panic attacks and axis 1 pathology. *Journal of Psychiatric Research, 40*, 691-699.
- Shephard, R. J., Cox, M. H., & Simper, K. (1981). An analysis of "Par-Q" responses in an office population. *Canadian Journal of Public Health, 72*, 37-40.
- Smits, J. A. J., Berry, A. C., Rosenfield, D., Powers, M. B., Behar, E., & Otto, M. W. (2008). Reducing anxiety sensitivity with exercise. *Depression and Anxiety, 25*, 689-699.
- Smits, J. A. J., Meuret, A. E., Zvolensky, M. J., Rosenfield, D., & Seidel, A. (2009). The effects of acute exercise on CO₂ challenge reactivity. *Journal of Psychiatric Research, 43*, 446-454.
- Smits, J. A. J., & Zvolensky, M. J. (2006). Emotional vulnerability as a function of physical activity among individuals with panic disorder. *Depression and Anxiety, 23*, 102-106.
- Strohle, A., Graetz, B., Scheel, M., Wittmann, A., Feller, C., Heinz, A., & Dimeo, F. (2009). The acute antipanic and anxiolytic activity of aerobic exercise in patients with panic disorder and healthy control subjects. *Journal of Psychiatric Research, 43*, 1013-1017.
- Taylor, S., Zvolensky, M. J., Cox, B. J., Deacon, B., Heimberg, R., G., Ledley, D. R., ... Bouvard, M. (2007). Robust dimensions of anxiety sensitivity: Development and initial

validation of the Anxiety Sensitivity Index-3. *Psychological Assessment, 19*, 176-188.

Telch, M. J., Lucas, J. A., Schmidt, N. B., Hanna, H. H., Jaimez, T. L., & Lucas, R. A. (1993).

Group cognitive-behavioral treatment of panic disorder. *Behavior Research and Therapy, 31*, 279-287.

Watt, M. C., Stewart, S. H., Lefaiivre, M., & Uman, L. S. (2006). A brief cognitive-behavioral

approach to reducing anxiety sensitivity decreases pain-related anxiety. *Cognitive Behaviour Therapy, 35*, 248-256.

Table 1

Demographic Characteristics and Baseline Measures for Exercise and No Exercise Groups

	<u>Exercise Group (n = 23)</u>			<u>No-Exercise Group (n = 22)</u>		
	<i>n</i> (%)	<i>M</i>	<i>SD</i>	<i>n</i> (%)	<i>M</i>	<i>SD</i>
Age		18.8	1.2		19.6	1.5
Gender						
Male	11 (47.8)			6 (27.3)		
Female	12 (52.2)			16 (72.7)		
Race						
Caucasian	21 (91.3)			20 (90.9)		
African-American	-			1 (4.5)		
Hispanic/Latino	2 (8.7)			-		
Other	-			1 (4.5)		
Anxiety Diagnosis						
PD	2 (8.7)			1 (4.5)		
Agoraphobia	1 (4.3)			-		
SAD	3 (13.0)			1 (4.5)		
Specific Phobia	6 (26.1)			4 (18.2)		
PTSD	1 (4.3)			-		
OCD	2 (8.7)			1 (4.5)		
GAD	6 (26.1)			4 (18.2)		
ASI-3		36.3	10.5		36.9	10.3
API		22.4	5.7		23.4	4.9

Note. The groups did not differ on any of the above measures.

Table 2

Heart Rate Means, Standard Deviations, and Group Differences at Each Time Point

	<u>Exercise Group</u>		<u>Rest Group</u>		<u>Group Differences</u>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>
2 minutes	140.48	27.56	80.45	16.63	8.29
5 minutes	147.38	24.27	79.75	16.20	10.44
10 minutes	152.86	20.57	79.75	16.93	12.69
15 minutes	148.57	9.86	78.00	15.90	17.49
20 minutes	144.43	8.77	80.95	17.46	15.11

Note. Exercise with $n = 23$; rest with $n = 22$. All group differences significant at $p < .001$.

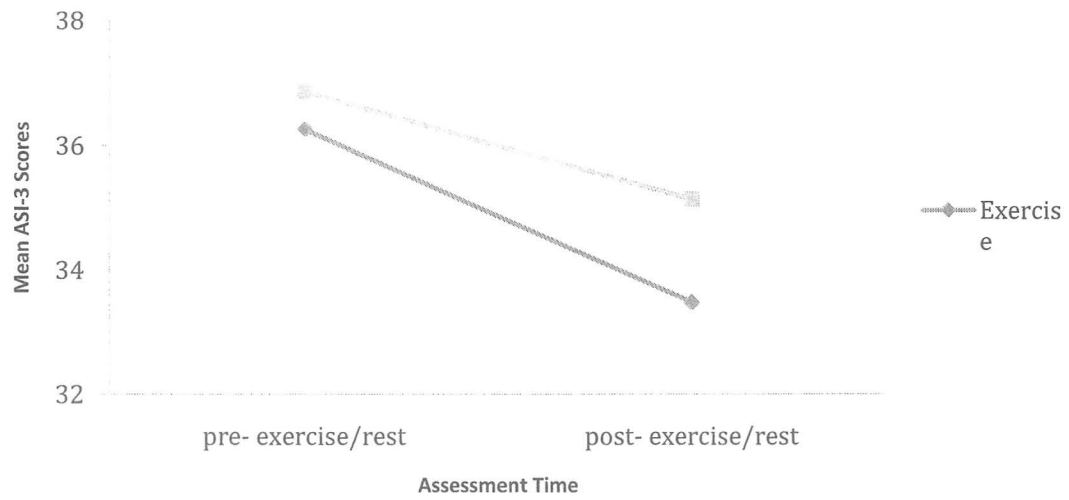


Figure 1. Mean ASI-3 scores for exercise and rest groups. This figure represents the mean ASI-3 scores for the exercise ($n = 23$) and rest ($n = 22$) groups at each assessment time.

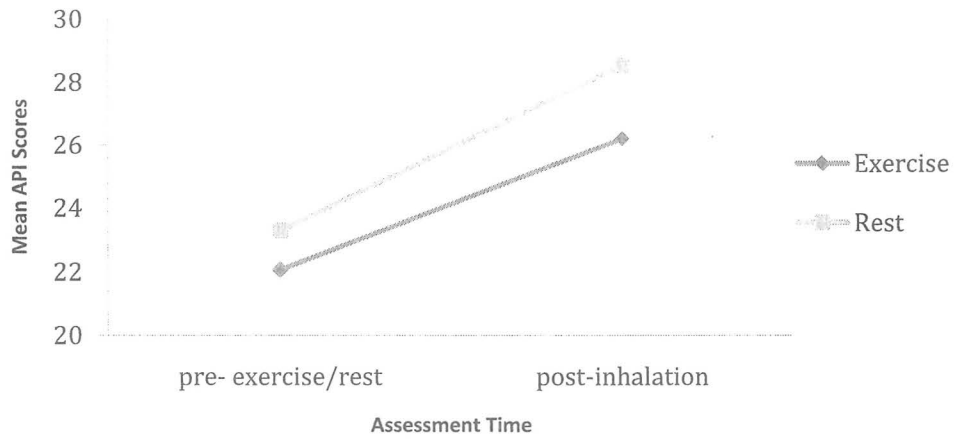


Figure 2. Mean API scores for exercise and rest groups. This figure represents the mean API scores for the exercise ($n = 21$) and rest ($n = 21$) groups at each assessment time.

Appendix A
IRB Approval Form

To: Joshua Broman-Fulks
Psychology
CAMPUS MAIL

From: _____
Dr. Timothy Ludwig, Institutional Review Board

Date: 10/14/2009

RE: Notice of IRB Approval by Expedited Review (under 45 CFR 46.110)

Study #: 09-0109

Study Title: Aerobic Exercise and Cognitive Appraisal to Reduce Anxiety Sensitivity

Submission Type: Modification

Expedited Category: (7) Research on Group Characteristics or Behavior, or Surveys, Interviews, etc.,(4) Collection of Data through Noninvasive Procedures Routinely Employed in Clinical Practice

Approval Date: 10/14/2009

Expiration Date of Approval: 2/15/2010

The modification requested which reduce the number of experimental groups from 4 to 2 and remove the stipulation requiring Melanie to observe and approve your exercise protocol has been approved by the Institutional Review Board for the period indicated. It has been determined that the risk involved in this modification is no more than minimal.

Investigator's Responsibilities:

Federal regulations require that all research be reviewed at least annually. It is the Principal Investigator's responsibility to submit for renewal and obtain approval before the expiration date. You may not continue any research activity beyond the expiration date without IRB approval. Failure to receive approval for continuation before the expiration date will result in automatic termination of the approval for this study on the expiration date.

You are required to obtain IRB approval for any changes to any aspect of this study before they can be implemented. Should any adverse event or unanticipated problem involving risks to subjects occur it must be reported immediately to the IRB.

CC:

Chelsea Price, Psychology

Appendix B
Screener Informed Consent

Dear Participant:

We are preparing to conduct a study that will look at various physical and emotional qualities among college students. We are looking for people with a variety of characteristics to participate in this study. To find people with these characteristics, we are asking people to complete a short set of questionnaires.

In order to contact you if you meet these characteristics, we may need to ask for your telephone number and email address. Further information concerning this study will be given to those who qualify. If you do not qualify, all identifying information will be removed from these forms.

You may ask the researcher any questions related to this research project, or you may contact Dr. Joshua Broman-Fulks at (828) 262-2726. This project has been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about your rights as a research participant should be directed to the Administrator for the IRB, Dr. Jay W. Cranston at (828) 262-2692 or Graduate Studies and Research, Appalachian State University, Boone, NC 28608.

Your consent to be in the preliminary study will be implied by filling out these questionnaires. Please feel free to keep this letter for your records.

Thank you for your participation.

Appendix C
Demographic Questionnaire

Name: _____ Email: _____ Telephone _____

#: _____

Age: _____ Gender: _____ Male _____ Female

Academic Status: _____ Freshman _____ Sophomore _____ Junior _____ Senior

Major: _____

Cumulative GPA: _____

Race/Ethnicity: _____ White or Caucasian _____ American-Indian or Alaskan Native
 _____ Black or African-American _____ Hispanic or Latino
 _____ Asian _____ Native Hawaiian or Other Pacific Islander
 _____ Other (please specify) _____

Are you currently involved in a regular exercise program? Yes No

- If yes, how many times per week do you exercise on average? _____
- If yes, how many minutes do you spend exercising each time you exercise? _____
- If yes, which type(s) of exercise do you participate in each week (check all that apply):
 - _____ Aerobic (walking, jogging, aerobics, stair stepping, cycling, swimming, etc.)
 - _____ Resistance Training (weight lifting, nautilus, etc.)
 - _____ Sports (basketball, football, tennis, dance, etc.)
 - _____ Other (please specify): _____
- How many times have you exercised in the past 2 weeks? _____

Have you ever been diagnosed with or treated for ADHD? Yes No

- If yes, what year(s) was that? _____

Have you ever been diagnosed with or treated for anxiety problems? Yes No

- If yes, what year(s) was that? _____

During your lifetime, have you ever had a panic attack? Yes No

- If yes, how many panic attacks have you had? (circle 1): 1-2 3-5 5-10 10-25 >25

Are you currently taking any psychiatric medications? Yes No

- If yes, please specify the name(s) and or type(s) (anti-anxiety, antidepressant, etc) of medication you are taking:

Do you currently use any health related supplements? Yes No

Have you ever been diagnosed with any of the following medical conditions?

- | | | |
|---|-----|----|
| - Asthma, chronic bronchitis, or other conditions that affect your breathing? | Yes | No |
| - Heart condition that prevents your participation in strenuous activity? | Yes | No |
| - Bone or joint problems that prevent your participation in strenuous activity? | Yes | No |
| - Diabetes? | Yes | No |

Appendix D
Exercise Group Informed Consent

Appalachian State University

**Informed Consent for Participating in
Research Projects involving Human Subjects**

Title of study: Psychological Functioning in College Students

Investigators: Joshua J. Broman-Fulks, Ph.D. & Chelsea A. Price, B.A.

Participant Name: _____

I. Purpose of the study:

The purpose of this study is to examine psychological functioning and exercise in college students. In this study, you will be asked to participate in an exercise program consisting of jogging on a treadmill.

II. Procedures:

Who can participate?

You must be 18 years old and in good physical health to participate in this study. If you have any physical conditions that would prevent you from exercising, or any breathing conditions (such as asthma) you cannot participate in this study. If you have questions about your health, you will need to get clearance from a health care provider prior to participating in this study. There may be fees associated with this service, for which you will be responsible. Women who are pregnant or planning to conceive during this study are strongly encouraged not to participate in this study.

Description and Explanation of Procedures:

If you choose to take part in this study, you will be asked to complete a session consisting of a structured interview assessing for anxiety symptoms and psychological functioning, a series of psychological states questionnaires, and an exercise session that will last approximately 20 minutes. The researcher will attach a heart monitor to you, which will be worn as a belt around the torso, with a receiver placed nearby on the treadmill. The exercise session will begin with two minutes of stretching exercises, followed by a two-minute warm up on the treadmill. Then, you will be asked to exercise on the treadmill for a period of 20 minutes at a comfortable aerobic pace. At the conclusion of the exercise, you will be provided with the opportunity to stretch for two minutes, and then asked to sit quietly in a chair for five minutes to allow for cool down. Additional psychological states questionnaires will then be completed following the exercise session. Next, you will be instructed on vital capacity breathing and will complete a brief inhalation task in which anxiety symptoms may be provoked. A third series of psychological questionnaires will be completed following the inhalation task. The entire session should take approximately 90 minutes to complete. You will be asked not to take any drugs or consume any alcohol for 24 hours prior to the exercise session. You will also be asked to complete a series of psychological states questionnaires one week after the exercise session which will take approximately 20 minutes.

When the study is complete and the results have been analyzed, the researcher will attempt to contact all participants of the study to invite them to come in for a debriefing session. In this session, participants will be informed of the findings of the study and given the opportunity to ask questions concerning these findings.

At any time for any reason, you may stop the procedure and withdraw from the study without penalty. You will be monitored at all times to ensure your safety, and the researcher may decide to discontinue the procedure if you display signs of distress.

III. Risks and Discomforts:

Although every effort will be made to minimize the occurrence of problems by screening participants and monitoring heart rate and behavior during the procedures, the possibility of experiencing some discomfort exists. During the completion of the questionnaires related to mood states, you might become uncomfortable or embarrassed. During the exercise session and inhalation task, you may experience increased heart rate, respiration rate, dizziness, hyperventilation, and/or perspiration. In the unlikely event of an accident occurring while on the treadmill, other possible discomforts that may be incurred during the exercise session include: skin wounds, bruises, sprains or strains, or pain or discomfort in the chest, neck, legs, or arms. If exhaustion, dizziness or hyperventilation occurs, the procedure will be immediately ceased and you will be asked to sit in a chair until you regain your composure. If the problem continues or an accident occurs in which injuries are incurred, you will be referred to the

ASU health center in order for a physician can assess and/or treat you.

IV. Benefits:

The information that you provide in this study may enable researchers to improve their understanding of the effects of physical activity on college students. This will be discussed with you further after you complete the study. You will receive course credit for your participation in this study. Other research and non-research options for obtaining course credit are available. Please see your class instructor for more information.

V. Extent of Anonymity and Confidentiality

All information obtained during this study is confidential. That is, we protect the privacy of subjects by withholding their names and other identifying information from all persons not connected with this study. The researcher will code all questionnaires and data by number and store them in a locked and secure area. Data that we may report in scientific journals or presentations will not include any information that identifies you as a participant in this study. Five years after the final publication of this study, all information and records will be destroyed.

VI. Compensation:

You will receive course credit for your participation in this study. You will receive 2 credits for completing this study. It is important that you complete both sessions in order to receive full credit for your participation in the study. You will not be penalized if you choose not to participate in or withdraw from this study.

VII. Freedom to Withdraw

Participation in this research is completely voluntary. Therefore, at any time for any reason, you may choose to stop and withdraw from the study without penalty.

Liability Statement:

If you experience physical or emotional problems because of your participation, please notify Dr. Broman-Fulks immediately. If any participant needs medical attention, the counseling and health centers on campus will be available for you at no extra cost.

Other Considerations:

If significant new information relating to this study becomes known which may relate to your willingness to continue to take part in this study, this information will be given to you by the investigator.

VIII. Approval of Research

This research project has been approved, as required, by the Institutional Review Board of Appalachian State University.

2/16/2009
IRB Approval Date

2/15/2010
Approval Expiration Date

IX. Subject's Responsibilities

I voluntarily agree to participate in this study. I have to following responsibilities: complete all questionnaires, exercise on treadmill, and to complete the inhalation task.

X. Subject's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

Date _____
Subject signature

Date _____
Witness (Optional except for certain classes of subjects)

Should I have any questions about this research or its conduct, I may contact:

Chelsea A. Price, (336) 880-5599, priceca@appstate.edu
Graduate Student, Clinical Health Psychology Masters Program, Appalachian State University, Boone, NC 28608

Dr. Joshua J. Broman-Fulks, (828) 262-2726, bromanfulksj@appstate.edu
Assistant Professor, Psychology Department, Appalachian State University, Boone, NC 28608

Dr. Lisa Curtin, 828-262-2729 curtinla@appstate.edu

Administrator, IRB, Psychology Department, Appalachian State University, Boone, NC 28608

You will be provided with a copy of this form for your records.

Appendix E
Non-Exercise Group Informed Consent

Appalachian State University

**Informed Consent for Participating in
Research Projects involving Human Subjects**

Title of study: Psychological Functioning in College Students

Investigators: Joshua J. Broman-Fulks, Ph.D. & Chelsea A. Price, B.A.

Participant Name: _____

I. Purpose of the study:

The purpose of this study is to examine psychological functioning in college students. In this study, you will be asked to participate in a cognitive task which requires mental attention.

II. Procedures:

Who can participate?

You must be 18 years old and in good physical health to participate in this study. If you have any breathing conditions (such as asthma) you cannot participate in this study. If you have questions about your health, you will need to get clearance from a health care provider prior to participating in this study. There may be fees associated with this service, for which you will be responsible. Women who are pregnant or planning to conceive during this study are strongly encouraged not to participate in this study.

Description and Explanation of Procedures:

If you choose to take part in this study, you will be asked to complete a session consisting of a structured interview assessing anxiety symptoms and psychological functioning and several series of psychological states questionnaires. The researcher will attach a heart monitor to you, which will be worn as a belt around the torso, with a receiver placed nearby. After you complete the structured interview and first set of psychological states questionnaires, you will be asked to sit in a room for 20 minutes before you complete the second set of psychological states questionnaires. Next, you will be instructed on vital capacity breathing and will complete a brief inhalation task in which anxiety symptoms may be provoked. A third series of psychological states questionnaires will be completed following the inhalation task. The entire session should take approximately 90 minutes to complete. You will be asked not to take any drugs or consume any alcohol for 24 hours prior to the exercise session. You will also be asked to complete a series of psychological states questionnaire one week after the first session which will take approximately 20 minutes.

When the study is complete and the results have been analyzed, the researcher will attempt to contact all participants of the study to invite them to come in for a debriefing session. In this session, participants will be informed of the findings of the study and given the opportunity to ask questions concerning these findings.

At any time for any reason, you may stop the procedure and withdraw from the study without penalty. You will be monitored at all times to ensure your safety, and the researcher may decide to discontinue the procedure if you display signs of distress.

III. Risks and Discomforts:

Although every effort will be made to minimize the occurrence of problems by screening participants and monitoring heart rate and behavior during the procedures, the possibility of experiencing some discomfort exists. During the completion of the questionnaires related to mood states, you might become uncomfortable or embarrassed. During the inhalation task, you may experience increased heart rate, respiration rate, dizziness, hyperventilation, and/or perspiration. If dizziness or hyperventilation occurs, the procedure will be immediately ceased and you will be asked to sit in a chair until you regain your composure. If the problem continues or an accident occurs in which injuries are incurred, the health clinic may be contacted so a physician can assess and/or treat you. There may be fees associated with this assessment/treatment, for which you will be responsible.

IV. Benefits:

The information that you provide in this study may enable researchers to improve their understanding of the effects of psychological processes on college students. This will be discussed with you further after you complete the study. You will receive course credit for your participation in this study. Other research and non-research options for obtaining course credit are available. Please see your class instructor for more information.

V. Extent of Anonymity and Confidentiality

All information obtained during this study is confidential. That is, we protect the privacy of subjects by withholding their names and other identifying information from all persons not connected with this study. The researcher will code all questionnaires and data by number and store them in a locked and secure area. Data that we may report in scientific journals or presentations will not include any information that identifies you as a participant in this study. Five years after the final publication of this study, all information and records will be destroyed.

VI. Compensation:

You will receive course credit for your participation in this study. You will receive 2 credits for completing this study. It is important that you complete both sessions in order to receive full credit for your participation in the study. You will not be penalized if you choose not to participate in or withdraw from this study.

VII. Freedom to Withdraw

Participation in this research is completely voluntary. Therefore, at any time for any reason, you may choose to stop and withdraw from the study without penalty.

Liability Statement:

If you experience physical or emotional problems because of your participation, please notify Dr. Broman-Fulks immediately. If any participant needs medical attention, the counseling and health centers on campus will be available for you at no extra cost.

Other Considerations:

If significant new information relating to this study becomes known which may relate to your willingness to continue to take part in this study, this information will be given to you by the investigator.

VIII. Approval of Research

This research project has been approved, as required, by the Institutional Review Board of Appalachian State University.

2/16/2009
IRB Approval Date

2/15/2010
Approval Expiration Date

IX. Subject's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities: complete all questionnaires, perform a cognitive task, and to complete the inhalation task.

X. Subject's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

Subject signature Date _____

Witness (Optional except for certain classes of subjects) Date _____

Should I have any questions about this research or its conduct, I may contact:

Chelsea A. Price, (336) 880-5599, priceca@appstate.edu
Graduate Student, Clinical Health Psychology Masters Program, Appalachian State University, Boone, NC 28608

Dr. Joshua J. Broman-Fulks, (828) 262-2726, bromanfulksj@appstate.edu
Assistant Professor, Psychology Department, Appalachian State University, Boone, NC 28608

Dr. Lisa Curtin, 828-262-2729 curtinla@appstate.edu
Administrator, IRB, Psychology Department, Appalachian State University, Boone, NC 28608

You will be provided with a copy of this form for your records.

Appendix F
Referral Information

If you are experiencing psychological distress and are interested in finding out more about it here are some places you can call.

ASU Counseling Center #828-262-3180

ASU Psychology Clinic #828-262-6639

Appendix G
Debriefing Protocol

Thank you again for participating in this study. I'd like to talk to you a minute about this experiment. I'm sure that you have learned, or will be learning, in your Psychology courses that sometimes there is more to a study than the investigator lets on. If we told you everything about the reason for the study, you might answer questionnaires somewhat differently than you would otherwise. You might pay more attention to the variables that I was interested in than you would normally. In my initial briefing, I did not explain the specific purpose of the study. Do you remember what I told you about the purpose of the study?

(Wait for response.)

Yes, that it had to do with psychological functioning in college students. However, the real purpose of the exercise was a little more specific than that. We were specifically interested in the effects of aerobic exercise on fear of anxiety sensations and reactivity to carbon dioxide inhalation. Not all participants in this study completed an exercise session so that we could compare results of participants who exercised to those who did not to determine if the aerobic exercise was producing an effect. The results of this study may be beneficial by showing the benefits of aerobic exercise as an easy and low cost treatment for people with high anxiety sensitivity and the benefits of exercise on psychological wellbeing.

The reason that we could not tell you the specific purpose of the study was that sometimes if you know the real purposes of the study you might have responded differently on the questionnaires. You may have attempted to feel the way you thought I wanted you to feel after exercising.

Are there any questions about the purpose of the study?

I would also like to request that you not discuss this study with anyone else because we may be using this design with other studies, and if people knew what the purpose of the study was, it could alter their responses. We want people to come in here and give their natural responses and not be influenced by knowing what we are studying. You can discuss it with others who have also participated in the study, but please do not talk about it with anyone else.

Does that make sense why it is important that other potential subjects don't know what the focus of the study is?

Great, then I appreciate you not discussing it with anyone. It will really help me with my project.

Thank you.

**Curriculum Vitae
Chelsea Ann Price**

ADDRESS

1113 Raleigh Court
High Point, NC 27262
priceca@appstate.edu
(336)-880-5599

EDUCATION

2008-present *Appalachian State University, Boone, NC*
Master of Arts in Clinical Health Psychology
Expected date of completion: December 2010

2005-2008 *Elon University, Elon, NC*
Bachelor of Arts in Psychology

2004-2005 *Meredith College, Raleigh, NC*
Major: Psychology

CLINICAL EXPERIENCE

06/2010-present **Clinical Internship**
Insight Human Services, Winston-Salem, NC
Child & Adolescent Substance Abuse Treatment Team
Supervisor: Samuel Gray, Psy.D.
Activities: Conduct individual psychotherapy sessions with clients; Co-facilitate adolescent intensive outpatient substance abuse group; Co-facilitate adolescent multifamily group for substance abuse; Create Person-Centered Plan; Case management and authorization requests for Medicaid or private insurance companies for adolescent receiving intensive outpatient services; Conduct intake assessments; Conduct psychological evaluations; Conduct disability evaluations; Conduct psychological testing; Facilitate therapy group for adolescent in detention; Conduct assessments and make treatment recommendations for adolescent in detention; Administer urine drug screens;

08/2009-05/2010 **Clinical Practicum II**
Watauga High School, Boone, NC
Assessment Support & Counseling Center
Supervisor: Kurt Michael, Ph.D.
Activities: Conduct individual psychotherapy sessions with clients; Use Cognitive-Behavioral Therapy, Dialectical-Behavior Therapy, and Interpersonal Therapy approaches for a variety of concerns including personality, mood, anxiety, suicidal ideation, self-injury, and academic

issues; Administer self-report depression and anxiety measures; Co-facilitate a Dialectical-Behavioral Therapy Skills Training group.

01/2009-05/2009

Clinical Practicum I

Appalachian State University, Boone, NC
Counseling & Psychological Services Center
Supervisor: Marion Zahn, Ph.D.

Activities: Conducted individual psychotherapy sessions with college students; Used Cognitive-Behavioral Therapy, Interpersonal Therapy, and Mindfulness approaches for a variety of concerns including anger management, interpersonal, mood, and anxiety issues.

08/2008-12/2008

Cognitive Behavioral Treatment Group Co-Facilitator

Grandfather Home for Children, Banner Elk, NC
Supervisor: Bob Hill, Ph.D.

Activities: Co-facilitated Post-Traumatic Stress Disorder group for children with a history of sexual abuse in a level 3 facility; Used Cognitive-Behavioral Therapy treatment manual.

RESEARCH EXPERIENCE

08/2008-present

Thesis

Appalachian State University, Boone, NC
Anxiety Research Lab
Supervisor: Joshua J. Broman-Fulks, Ph.D.

Activities: Developed research study; Presented research proposal to thesis committee for approval; Completed experimental study investigating anxiety sensitivity and aerobic exercise; Compiled database and analyzed research findings; Presented findings and implications of research to committee; Submitted thesis to graduate school for approval.

08/2008-05/2010

Research Assistant

Appalachian State University, Boone, NC
Anxiety & Exercise Research Lab
Supervisor: Joshua J. Broman-Fulks, Ph.D.

Activities: Supervise undergraduate and graduate research assistants working in the laboratory; Create and train research assistants in study protocol procedures; Conduct screenings to determine potential psychopathology in possible participants; Schedule participants for study sessions; Conduct diagnostic interviews (SCID).

01/2006-05/2008

Research Assistant

Elon University, Elon, NC
Supervisor: Alexa Darby, Ph.D.

Activities: Conducted focus groups and interviews; Transcribed focus group and interview data; Trained in coding of qualitative data.

PUBLICATIONS

1. Darby, A., Knight-McKenna, M., Spingler, M., & **Price, C.** (2008, fall). Uncovering attitudes toward high poverty schools. *Academic Exchange Quarterly*, 12(3), 67-71.

MANUSCRIPTS IN PREPARATION

1. Darby, A., Mihans, R., Lambine, M., Glazer, K., Price, C., & Stanfield, A. (In Progress). Riding the rollercoaster: First year teacher emotions.

TECHNICAL REPORTS

1. Gibson, A., Gonzalez, K., **Price, C.**, Scharback, K., & Shafer, W. (2007, April). *Volunteer Satisfaction Program Evaluation* for Family Abuse Services Center, Burlington, NC.

PRESENTATIONS

1. **Price, C. A.**, Combs, M. A., Zawilinski, L. L., & Orlando, C. M. (2010, March). *Anxiety Sensitivity and Quality of Life in a Community Sample*. Poster presented at convention of the Southeastern Psychological Association, Chattanooga, TN.
2. Zawilinski, L. L., **Price, C. A.**, Orlando, C. M., & Broman-Fulks, J. B. (2010, March). *Effects of a single bout of exercise on anxiety sensitivity*. Poster presented at convention of the Anxiety Disorder Association of America, Baltimore, MD.
3. Trout, K. L., **Price, C. A.**, Broman-Fulks, J. B., Canu, W. H., & Neiman, D. C. (2009, November). *Gender Differences in Anxiety Sensitivity Index-3 Dimensions*. Poster presented at the 43rd annual convention of the Association of Behavioral and Cognitive Therapies, New York, NY.
4. Toomey, K.J, Broman-Fulks, J.J., Bondy, C.L., **Price, C.A.** (2009, November). *Effects of anxiety sensitivity on gambling*. Poster presented at the 43rd annual convention of the Association for Behavior and Cognitive Therapies, New York, NY.
5. Knight-McKenna, M., Darby, A., & **Price, C.** (2007, October). *Academic Service-Learning for Teacher Candidates' in Title I Schools*. Paper presented at the meeting of the International Society for Exploring Teaching and Learning, Atlanta, GA.
6. **Price, C.**, Knight-McKenna, M., & Darby, A. (2008, April). *Teacher Candidates' Perspectives Toward Title I Schools After Academic Service-Learning Experiences*. Paper presented at the meeting of the National Conference for Undergraduate Research, Salisbury, MA.

PROFESSIONAL HONORS AND MEMBERSHIPS

Pi Gamma Mu, International Honors Society in Social Sciences
American Psychological Association (Student Member)
California Psychological Association (Student Member)
Association of Behavioral and Cognitive Therapies (Student Member)
Psychology Graduate Student Organization

References available upon request