CAN A SINGLE BOUT OF AEROBIC EXERCISE REDUCE ANXIETY SENSITIVITY? A RANDOMIZED CONTROLLED TRIAL

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Daniel Marc LeBouthillier, candidate for the degree of Master of Arts in Clinical Psychology, has presented a thesis titled, *Can a Single Bout of Aerobic Exercise Reduce Anxiety Sensitivity? A Randomized Controlled Trial*, in an oral examination held on July 17, 2014. The following committee members have found the thesis acceptable in form and content, and that the candidate demonstrated satisfactory knowledge of the subject material.

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Abstract

A growing body of research supports the benefits of exercise for a variety of mental disorders, including anxiety. Several mechanisms have been posited for the anxiolytic effects of exercise, including reductions in anxiety sensitivity (i.e., fear of arousal-related sensations, based on the beliefs that these sensations may have harmful or negative consequences) through exposure to these feared bodily sensations. Studies on aerobic exercise lend support to this hypothesis; however, research comparing exercise to placebo controls and evidence for the dose-response relationship between exercise and reductions in anxiety sensitivity are lacking. The present trial was designed to investigate reductions in anxiety sensitivity following a single session of exercise. A total of 41 participants were randomized to complete either a 20-minute session of aerobic exercise or a placebo stretching control. Anxiety sensitivity was measured at baseline, immediately post-intervention, and at approximately 3-day and 7-day follow-up using the Anxiety Sensitivity Index-3 (ASI-3). Individuals in the aerobic exercise group experienced significant decreases in ASI-3 Total and on the Cognitive Concerns and Social Concerns dimensions from baseline to 3-day follow-up and on all four dimensions of anxiety sensitivity at 7-day follow-up. Individuals in the control group had increases in ASI-3 Total and Social Concerns scores from baseline to post-treatment, 3-day follow-up, and 7-day follow-up. Clinically significant change in ASI-3 Total scores was observed in several individuals in the aerobic exercise group, but not in the control group. The present trial included individuals with a wide range of anxiety sensitivity severity and the results suggest that reductions in anxiety sensitivity following aerobic exercise are not exclusive to individuals with high levels of the trait.
Additionally, the magnitude of reduction in anxiety sensitivity did not vary according to individuals’ level of the trait at baseline. The results of the present trial have important implications for aerobic exercise as a potential adjunct to or temporary substitute for psychotherapy aimed at reducing anxiety.
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Dedication

To my mother, Annette, whose love and dedication has inspired me more than she can imagine. To my partner, Ben, who has and continues to foster my dreams in every way possible. To my dear friend, Mike, who found my academic home.
# Table of Contents

Abstract .......................................................................................................................... i

Acknowledgements ......................................................................................................... iii

Dedication ........................................................................................................................ iv

Table of Contents ........................................................................................................... v

List of Tables ................................................................................................................... viii

List of Figures ................................................................................................................ ix

List of Appendices .......................................................................................................... x

1. Introduction ................................................................................................................ 1

   1.1 Overview ................................................................................................................. 1

   1.2 Anxiety Sensitivity ............................................................................................... 2

   1.3 Physical Exercise ................................................................................................. 6

   1.4 Potential Mechanisms for the Anxiolytic Effects of Exercise ......................... 9

       1.4.1 Physiological changes .................................................................................. 9

       1.4.2 Improved sleep ........................................................................................... 10

       1.4.3 Mastery ....................................................................................................... 11

       1.4.4 Changes in affect ...................................................................................... 11

       1.4.5 Behavioural activation and distraction ......................................................... 12

       1.4.6 Reductions in anxiety sensitivity ................................................................. 12

2. Investigation ................................................................................................................. 16

   2.1 Purpose .................................................................................................................. 16

   2.2 Hypotheses .......................................................................................................... 18

   2.3 Participants .......................................................................................................... 18
2.4 Screening Measures

2.4.1 Physical Activity Readiness Questionnaire

2.4.2 Physical Activity Readiness Medical Questionnaire

2.5 Psychological and Lifestyle Measures

2.5.1 Anxiety Sensitivity Index – 3

2.5.2 Healthy Physical Activity Participation Questionnaire

2.5.3 Manipulation check

2.6 Physiological Measurements

2.6.1 Skinfold measurement

2.6.2 Vital signs

2.7 Equipment

2.7.1 Stationary cycle

2.7.2 Heart rate monitor

2.8 Procedure

2.8.1 Online measures and initial phone screen

2.8.2 Pre-treatment in-lab testing and information session

2.8.3 Aerobic exercise paradigm

2.8.4 Stretching control paradigm

2.8.5 Post-treatment and follow-up psychological testing

2.9 Analyses

2.9.1 Hypothesis 1

2.9.2 Hypothesis 2

3. Results
3.1 Participant Characteristics ..................................................................................... 32
3.2 Hypothesis 1 .............................................................................................................. 34
3.3 Hypothesis 2 .............................................................................................................. 44
4. Discussion .................................................................................................................. 45
5. References ................................................................................................................ 53
6. Appendices ................................................................................................................. 67
List of Tables

Table 1. Participant characteristics. ................................................................. 35

Table 2. Anxiety sensitivity scores at baseline, post-treatment, and follow-up......... 36
List of Figures

Figure 1. Study protocol................................................................................................................. 25
Figure 2. Participant flow.................................................................................................................. 33
Figure 3. ASI-3 Total scores before, during, and after the intervention................................. 37
Figure 4. ASI-3 Cognitive scores before, during, and after the intervention......................... 39
Figure 5. ASI-3 Social scores before, during, and after the intervention................................. 41
Figure 6. ASI-3 Physical scores before, during, and after the intervention............................. 43
List of Appendices

Appendix A: Physical Activity Readiness Questionnaire................................................. 67
Appendix B: Anxiety Sensitivity Index - 3............................................................................. 68
Appendix C: Healthy Physical Activity Participation Questionnaire.............................. 70
Appendix D: Research Ethics Board Approval Form.......................................................... 71
1. Introduction

1.1 Overview

The physical and psychological benefits of regular and moderate to vigorous exercise (i.e., physical activity that causes a person to perspire, breathe more heavily, or become out of breath; Statistics Canada, 2013) are well established in modern scientific literature (Penedo & Dahn, 2005). Though efforts to disseminate this information and encourage greater participation in physical activity are widespread, few Canadians get the weekly recommended level of activity needed to reap the benefits (i.e., 150 minutes of moderate-to-vigorous physical activity in increments of at least 10 minutes; Public Health Agency of Canada, 2012; Statistics Canada, 2013). Research has shown great potential for the role of exercise in treating a range of mental disorders, including generalized anxiety, social anxiety, panic, posttraumatic stress, and obsessive-compulsive disorder (see Asmundson et al., 2013, for a review), as well as substance use and eating disorders (Stathopoulou, Powers, Berry, Smits, & Otto, 2006). Aerobic exercise may exert its anxiolytic effects through a variety of mechanisms, including reductions in anxiety sensitivity due to interoceptive exposure (Asmundson et al., 2013). Anxiety sensitivity and interoceptive exposure are defined and discussed in greater detail in the following section. A small body of research has provided preliminary support for the effect of 2-week aerobic exercise paradigms in reducing anxiety sensitivity (Broman-Fulks, Berman, Rabian, & Webster, 2004; Broman-Fulks & Storey, 2008; Smits et al., 2008); however, research comparing aerobic exercise to placebo controls are lacking, as are investigations on the effect of acute aerobic exercise in reducing anxiety sensitivity.
The current thesis is structured as follows. First, an overview of anxiety sensitivity and the associated correlates is presented. Second, prevalence and mental health correlates of exercise are discussed, with a larger focus on anxiolytic benefits. Third, potential mechanisms of action for the anxiolytic effects of exercise are reviewed, including reductions in anxiety sensitivity through interoceptive exposure. Fourth, a more in-depth discussion of the relationship between anxiety sensitivity and physical exercise is presented. Finally, an overview of the present trial is presented, including purpose, hypotheses, methodology, results, limitations, and implications.

1.2 Anxiety Sensitivity

Anxiety Sensitivity is the fear of arousal-related sensations, based on the beliefs that these sensations may have harmful or negative consequences (Reiss & McNally, 1985). Although anxiety sensitivity bears resemblance to trait anxiety, the two are conceptually distinct; trait anxiety is characterized by fearful response to stressors, while anxiety sensitivity involves fearful response to anxiety symptoms (McNally, 1989). The theoretical distinction has been supported empirically by factor analytic research (Sandin, Chorot, & McNally, 2001). Anxiety sensitivity has been conceptualized as an anxiety amplifier; that is, when individuals with high anxiety sensitivity become anxious, they begin to fear their own anxiety-related sensations (e.g., increased heart rate, sweating, muscle tension, shortness of breath; Stewart & Watt, 2007) and become even more anxious (Taylor et al., 2007). To illustrate, a student taking a test may fear that her racing thoughts are a sign that her concentration is becoming impaired, which increases her fear and further impacts her concentration. Anxiety sensitivity predicts anxiety in a variety of settings, such as public speaking (Behnke & Sawyer, 2001) and performance
situations (Thibodeau, Gómez-Pérez, & Asmundson, 2012). In addition, anxiety sensitivity may be a better predictor of performance anxiety than trait anxiety (Stephenson & Quarrier, 2005). Anxiety sensitivity has been linked to several anxiety disorders, such as panic disorder (Schmidt, Zvolensky, & Maner, 2006), agoraphobia (Hayward & Wilson, 2007), and generalized anxiety disorder (Tull, Stipelman, Salters-Pedneault, & Gratz, 2009), as well as trauma- and stressor-related disorders, such as and posttraumatic stress disorder (Bernstein et al., 2005). The construct of anxiety sensitivity appears stable over time (Rodriguez, Bruce, Pagano, Spencer, & Keller, 2004), although reductions have been observed following different interventions, such as aerobic exercise (Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008; Smits et al., 2008) and cognitive behavioural therapy (Gallagher et al., 2013).

Originally, anxiety sensitivity was conceptualized as a unidimensional construct (Peterson & Reiss, 1993); however, research has subsequently shifted to a multidimensional conceptualization of anxiety sensitivity (Asmundson, Weeks, Carleton, Thibodeau, & Fetzner, 2011) that includes three lower-order factors consisting of Physical Concerns (i.e., fear of somatic sensations), Cognitive Concerns (i.e., cognitive dyscontrol), and Social Concerns (i.e., fear of publicly observable symptoms; Taylor, 1999). Anxiety sensitivity was first measured using the Anxiety Sensitivity Index (ASI; Peterson & Reiss, 1993). The multidimensional use of the ASI raised concerns over reliability and content validity because the Physical Concerns subscale included more items than the Cognitive Concerns and Social Concerns subscales (Taylor et al., 2007). Furthermore, some items on the ASI may target different dimensions of anxiety sensitivity. The ASI-Revised (Taylor & Cox, 1998a) and the Anxiety Sensitivity Profile...
(Taylor & Cox, 1998b) were subsequently developed to address these issues, but had unreliable factor structures (Taylor et al., 2007). The third iteration of the ASI, the ASI-3 (Taylor et al., 2007), was designed to be multidimensional and maintains the original three factors and has robust psychometric properties. Subsequent research supports the psychometric properties of the measure, including factor structure (Wheaton, Deacon, McGrath, Berman, & Abramowitz, 2012) as well as convergent and discriminant validity (Kemper, Lutz, Bähr, Rüddel, & Hock, 2012). The ASI-3 is currently the standard measure for the assessment of anxiety sensitivity.

Although there have been significant improvements in the measurement of anxiety sensitivity using the ASI-3, the interpretation of anxiety sensitivity scores has been subject to considerable debate. In particular, some research suggests that anxiety sensitivity has a taxonic structure (e.g., Bernstein et al., 2010; Zvolensky, Forsyth, Bernstein, & Leen-Feldner, 2007), while other research suggests the construct is dimensional (e.g., Broman-Fulks et al., 2008, 2010). Methodological limitations have been suggested to explain these differing findings. Research supporting the taxonomic classification of anxiety sensitivity has often made use of redundant taxometric analyses and lacks objective data interpretation methods (Asmundson et al., 2011). In contrast, research utilizing non-redundant mathematical analyses and quantifiable means of data interpretation supports the dimensional conceptualization of anxiety sensitivity (Asmundson et al., 2011; Broman-Fulks et al., 2010).

Anxiety sensitivity as a higher-order construct has been related to anxiety and trauma- and stressor-related disorders and, as noted above, its three lower-order constructs appear to have stronger links to specific mental disorders. Studies suggest that
Physical Concerns are most strongly related to panic (Rector, Szacun-Shimizu, & Leybman, 2007), that Cognitive Concerns are most related to posttraumatic stress disorder (Vujanovic, Zvolensky, & Bernstein, 2008) and generalized anxiety disorder (Rodriguez et al., 2004), and that Social Concerns are most strongly related to social phobia (Wheaton et al., 2012). The differential associations suggest anxiety sensitivity is a construct broadly related to psychopathology in different ways. Interventions aimed at reducing anxiety sensitivity (e.g., aerobic exercise) appear to be effective in reducing anxiety sensitivity and its lower order factors (Broman-Fulks & Storey, 2008) and, therefore, have the potential to be useful in treating a variety of mental ailments.

Emerging evidence suggests that reductions in anxiety sensitivity may be an important mechanism of change in cognitive behavioural therapy. Cognitive behavioural therapy appears to be effective in reducing anxiety sensitivity in individuals with anxiety and mood disorders (Boswell et al., 2013). Reductions in anxiety sensitivity are also associated with reduced disorder severity ratings at post-treatment and at 6-month follow-up. When compared to a control condition, brief intervention programs for anxiety sensitivity consisting of cognitive behavioural techniques such as psychoeducation and interoceptive exposure can reduce risk of Diagnostic and Statistical Manual of Mental Disorders (4th ed., text rev.; DSM–IV–TR; American Psychiatric Association, 2000) Axis I psychopathology at 2-year follow-up (Schmidt et al., 2007). A randomized controlled trial of cognitive behavioural therapy for panic disorder suggests anxiety sensitivity mediates the effect of therapy on symptoms of panic and global disability (Smits, Powers, Cho, & Telch, 2004).
Despite the evidence that reductions in anxiety sensitivity serve as change mechanisms in cognitive behavioural therapy, robust evidence for the relationship remains sparse. A recent study by Gallagher and colleagues (2013) was designed to assess anxiety sensitivity as a mechanism of change in cognitive behavioural therapy. Specifically, the authors assessed temporal precedence of change and analyzed intra-individual changes in symptoms. A total of 361 individuals with a primary diagnosis of panic disorder underwent 11 sessions of cognitive behavioural therapy (including interoceptive and in vivo exposure) over a maximum of 18 weeks (Gallagher et al., 2013). Results indicated that changes in anxiety sensitivity occurred early during treatment and that the changes both preceded and predicted changes in panic disorder symptoms; as such, reducing anxiety sensitivity may have important and broad implications for treatment outcomes.

1.3 Physical Exercise

The Public Health Agency of Canada (2012) recommends that adults should engage in moderate to vigorous physical activity (i.e., physical activity that causes a person to perspire, breathe more heavily, or become out of breath; Statistics Canada, 2013) for at least two-and-a-half hours weekly and in periods of at least 10 minutes in order to achieve health benefits. Approximately 15% of Canadians (17% of males and 13% of females) meet these guidelines (Statistics Canada, 2013); moreover, Canadian adults spend approximately 10 waking hours a day on average in sedentary activities (i.e., sitting or lying down). The discrepancy between recommended and actual exercise levels may be due to insufficient self-motivation or self-efficacy, inappropriate health beliefs, or lack of an internal locus of control (Dishman, 1994). In addition, sedentary
behaviour is associated with negative health outcomes, including obesity, diabetes, and cancer independently of individuals’ engagement in moderate to vigorous exercise (Tremblay, Colley, Saunders, Healy, & Owen, 2010). There is also evidence for a dose-response relationship between sedentary behaviour and a greater likelihood of later having a mental disorder (Sanchez-Villegas et al., 2008); in other words, individuals who spend a greater amount of time in sedentary activities are at greater risk of developing a mental disorder in the future.

Several studies support the mental health benefits of exercise. A meta-analysis of 11 treatment studies in individuals with depression showed large effect sizes in favour of exercise over control conditions (Stathopoulou et al., 2006). Epidemiological evidence suggests individuals who report engaging in physical activity “regularly” have a lower prevalence of depression, panic attacks, social phobia, specific phobia, and agoraphobia compared to individuals who report engaging in physical activity “never,” “rarely,” or “occasionally” (Goodwin, 2003). Research investigating the effect of exercise in treating psychological disorders is limited both by the number of studies and by methodological issues (e.g., small samples, lack of controls, and limited attention to maintenance of treatment gains); however, physical exercise may be effective in treating anxiety disorders (e.g., generalized anxiety disorder, social anxiety, and panic disorder), obsessive-compulsive disorder, and posttraumatic stress disorder (see Asmundson et al., 2013, for a review), as well as substance use and eating disorders (Stathopoulou et al., 2006). Epidemiological studies have reported other mental health correlates of regular exercise, including lower neuroticism, greater extraversion, and greater sensation-seeking (De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006), as well as lower
hostility, lower perceived stress, greater social integration, and a more positive outlook on life (Hassmén, Koivula, & Uutela, 2000).

Research on the anxiolytic properties of physical activity has investigated the efficacy of a wide range of exercise paradigms, including yoga (Field, Diego, & Hernandez-Reif, 2010; Streeter et al., 2007); Tai Chi (Hoffmann-Smith, Ma, Yeh, DeGuire, & Smith, 2009); low-, moderate-, and high-intensity resistance training (Bibeau, Moore, Mitchell, Vargas-Tonsing, & Bartholomew, 2010; Tsutsumi et al., 1998; Tsutsumi, Don, Zaichkowsky, & Delizonna, 1997); and aerobic exercise (Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008; Raglin & Wilson, 1996; Smits et al., 2008). A number of populations have also been studied, including healthy university students (Bartholomew & Linder, 1998; Bibeau et al., 2010), university students with high anxiety sensitivity (Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008; Smits et al., 2008), university-level athletes (Raglin & Wilson, 1996), healthy adults (Field et al., 2010; Streeter et al., 2007), highly anxious adults (Hoffmann-Smith et al., 2009), and sedentary older adults (Tsutsumi et al., 1998). Overall, several types of exercise may have anxiolytic effects in different populations. More specifically, yoga appears to be effective in reducing anxiety in healthy adults (Field et al., 2010; Streeter et al., 2007), as is Tai Chi in both healthy (Field et al., 2010) and highly anxious (Hoffmann-Smith et al., 2009) adults. Moderate and high-intensity resistance training appears effective in reducing anxiety in sedentary older adults (Tsutsumi et al., 1998). In university students, high-intensity (i.e., 75-85% of one repetition maximum) resistance training immediately increases anxiety, and low intensity (i.e., 40-50% of one repetition maximum) resistance training immediately decreases anxiety (Bartholomew & Linder,
1998); however, both low and high intensity resistance training are associated with reduced anxiety 20 and 40 minutes following exercise (Bibeau et al., 2010). Light to heavy aerobic exercise (i.e., cycling at 40, 60, or 70% peak oxygen consumption) reduces anxiety in university-level athletes (Raglin & Wilson, 1996). Aerobic exercise also reduces anxiety sensitivity in university students with high levels of the trait (Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008; Smits et al., 2008).

1.4 Potential Mechanisms for the Anxiolytic Effects of Exercise

Despite the beneficial effects of exercise in reducing anxiety discussed above, little research has empirically tested the mechanisms through which exercise reduces anxiety (Asmundson et al., 2013). In a recent review of the anxiolytic effects of exercise, Asmundson and colleagues (2013) suggested several potential mechanisms of action, both physiological and psychological in nature. The potential mechanisms include physiological adaptations, behavioural activation and distraction, reductions in anxiety sensitivity through interoceptive exposure, improvements in sleep, mastery, and self-efficacy, and changes in affective status. The mechanisms most relevant to the present trial are described below. The present trial specifically follows a line of research investigating the anxiolytic effects of aerobic exercise paradigms; as such, subsequent sections will focus on the anxiolytic effects of aerobic exercise.

1.4.1 Physiological changes. Aerobic exercise is accompanied by many physiological benefits associated with decreased levels of stress and anxiety. For example, individuals who report participating “heavily” in aerobic activities have greater levels of norepinephrine and prolactin when initially exposed to psychological stressors and show faster physiological (i.e., heart rate) and subjective (i.e., reported anxiety)
recovery post-exposure compared to individuals who report no participation in aerobic activities (Sinyor & Schwartz, 1983). Repeated exercise may confer resistance to arousal because it produces increases in metabolic heat production and homeostatic changes similar to anxiety-related neurochemical processes (Lim, Byrne, & Lee, 2008). Relatively short aerobic exercise paradigms (i.e., 50-minutes of jogging at less than 50% heart rate reserve five times weekly for 8 weeks) have been linked with increased maximal oxygen uptake and lung capacity (Nabkasorn et al., 2006), both of which are negatively associated with anxiety symptoms in individuals with panic disorder and social anxiety disorder (Blechert, Wilhelm, Meuret, Wilhelm, & Roth, 2010). Other endogenous factors, such as brain-derived neurotropic factors, endorphins, endocannabinoids, norepinephrine, and the hypothalamic-pituitary-adrenal axis may also play an important role in reducing anxiety (Wipfli, Rethorst, & Landers, 2008).

The physiological changes that accompany increased physical activity are unlikely to completely account for the anxiolytic effects observed. Indeed, reductions in anxiety and anxiety sensitivity have been observed after as little as six 20-minute sessions of aerobic exercise over a 2-week period (Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008; Smits et al., 2008). Large reductions in anxiety sensitivity have been observed after just one session (Broman-Fulks & Storey, 2008). Reductions in anxiety and anxiety sensitivity would be unlikely to result in significant physiological changes after such short periods of increased aerobic activity.

1.4.2 Improved sleep. Longitudinal research suggests there is a significant bidirectional association between anxiety and sleep disturbances over a year (Jansson-Fröjmark & Lindblom, 2008). Persistent sleep disturbances in childhood are also
associated with greater risk of anxiety disorders in adulthood (Gregory et al., 2005). Improvements in sleep could therefore reduce both short-term and long-term anxiety. Aerobic exercise may alleviate anxiety by depleting the body of energy stores, promoting tissue breakdown, and increasing body temperature, all of which promote sleep (Youngstedt, 2005).

**1.4.3 Mastery.** Aerobic exercise may contribute to a feeling of mastery or self-efficacy because it provides a feeling of accomplishment stemming from the individual’s ability to overcome the challenges of exercise (Petruzzello, Landers, & Hatfield, 1991). Exercise aimed at increasing self-efficacy (i.e., martial arts) appears to be more effective in reducing anxiety than exercise aimed at merely maintaining self efficacy (i.e., stationary cycling; Bodin & Martinsen, 2004). The intensity of exercise may also play a role in this relationship, such that self-efficacy is associated with reductions in anxiety in moderate intensity exercise, but not in low or high intensity exercise (Katula, Blissmer, & McAuley, 1999).

**1.4.4 Changes in affect.** Acute aerobic exercise is associated with immediate and short-term increases in positive affect, particularly at low intensity, dose, and duration (Reed & Ones, 2006). Regular aerobic exercise is also associated with increased positive affect when performed at low intensity but relatively high frequency (i.e., 3-5 times weekly for 10-12 weeks; Reed & Buck, 2009). Positive changes in mood following aerobic exercise appear to be consistent and immediate even in clinical populations, such as individuals with obsessive-compulsive disorder (Abrantes et al., 2009).
1.4.5 **Behavioural activation and distraction.** Changes in behaviour patterns associated with physical activity can lead to decreases in social withdrawal or inaction. The changes serve as a form of behavioural activation for treating posttraumatic stress disorder. For example, a study of veterans showed that a 16-week manualized behavioural activation treatment consisting of semi-structured activities was effective in reducing severity of posttraumatic stress disorder symptoms (Jakupcak et al., 2006). Engagement in exercise provides the opportunity for distraction from negative thoughts that may be prevalent in individuals with anxiety disorders (Morgan, 1985; Salmon, 2001). The use of distraction during exercise, however, may reduce the anxiolytic properties of exercise from other mechanisms (Asmundson et al., 2013). For example, the use of distraction may compete with other therapeutic interventions, such as interoceptive exposure, by shifting the individual’s focus away from feared bodily sensations and preventing habituation to these sensations. Inducing distraction from feared bodily sensations could also potentially reinforce avoidance behaviours. Previous research on the anxiolytic effects of exercise has avoided the use of distraction by asking participants to rate their level of distress regularly during exercise (Smits et al., 2008); however, researchers have acknowledged the potential confounding effects of non-specific factors such as behavioural activation in their investigations of other anxiolytic mechanisms (Broman-Fulks & Storey, 2008; Smits et al., 2008).

1.4.6 **Reductions in anxiety sensitivity.** The reduction of fear typically involves exposure to the feared object or situation (Foa & Kozak, 1986). In the case of anxiety sensitivity, treatment usually involves repeated exposure to anxiety-related sensations (e.g., increased heart rate, sweating, muscle tension, shortness of breath; Stewart & Watt,
in order to demonstrate that they are innocuous rather than harmful. This procedure is known as interoceptive exposure. Contemporary literature supports interoceptive exposure as a method to reduce anxiety sensitivity (Smits et al., 2008). Aerobic exercise has recently been suggested as a form of interoceptive exposure because it produces physiological reactions similar to those associated with anxiety (Asmundson et al., 2013).

Research on the relationship between physical activity and anxiety sensitivity suggests individuals with high anxiety sensitivity report less vigorous exercise and lower fitness than individuals with lower levels of anxiety sensitivity (Goodin et al., 2009; McWilliams & Asmundson, 2001; Moshier et al., 2012; Smits & Zvolensky, 2006). Research on fitness and anxiety sensitivity has utilized self-reported measures as proxies for objective measures of fitness; however, self-reports of physical activity have low-to-moderate correlation with direct measures (Prince et al., 2008) and, relative to direct measures of physical activity, self-reports tend to provide greater overestimations of vigorous exercise than low-to-moderate intensity exercise. As such, the accuracy of fitness self-reports may differ based, in part, on anxiety sensitivity and individuals with high anxiety sensitivity may report lower fitness levels because they are more fearful of their bodily sensations. For example, a person with high anxiety sensitivity may believe that feelings of exertion and increased heart rate during exercise are indicative of poor fitness, rather than of a normal physiological reaction to increased activity.

The first study to examine the effects of aerobic exercise in individuals with high anxiety sensitivity used a paradigm consisting of six 20-minute sessions of treadmill exercise at high intensity (i.e., 60-90% of predicted maximum heart rate) or low intensity
(i.e., walking at a speed of 1 mile per hour) over the course of 2 weeks (Broman-Fulks et al., 2004). High anxiety sensitivity was operationalized as having a score of 25 or more on the ASI. The results suggested that both high- and low-intensity exercise lead to decreases in anxiety sensitivity. Although ASI subscales were not assessed in this study, high-intensity exercise was associated with reductions in fear of anxiety-related physical sensations (e.g., increased heart rate, breathing, and perspiration), as measured by the Body Sensations Questionnaire (Chambless, Caputo, Bright, & Gallagher, 1984). The high-intensity exercise paradigm was associated with other benefits, such greater rate of response to treatment and more rapid reductions in overall levels of anxiety sensitivity.

Subsequent research on individuals with high anxiety sensitivity, in this case operationalized as a score of more than 28 on the ASI-R, has suggested that aerobic exercise (i.e., six 20-minute sessions of brisk walking or jogging on a treadmill at 60% to 90% of maximum heart rate, over the course of 2 weeks) leads to an overall decrease in anxiety sensitivity compared to a non-exercise control, with treatment gains maintained at 1-week follow-up (Broman-Fulks & Storey, 2008). Participants in the aerobic exercise group showed reductions in all four ASI-R subscales (i.e., Fear of Respiratory Symptoms, Fear of Cardiovascular Symptoms, Fear of Publicly Observable Anxiety Reactions, and Fear of Cognitive Dyscontrol; Taylor & Cox, 1998). Interestingly, no further significant decreases in ASI-R global or subscale scores were observed following the first exercise session. Broman-Fulks and Storey’s (2008) results suggest that aerobic exercise can lead to rapid changes in anxiety sensitivity that can be maintained in the short term with continued exercise.
Only one study to date has compared the efficacy of aerobic exercise to cognitive therapy (Smits et al., 2008). Individuals with high anxiety sensitivity, here operationalized by a score of 25 or more on the ASI, were randomized to a 2-week aerobic exercise paradigm (consisting of six 20-minute sessions of treadmill running at 70% of estimated maximum heart rate), a 2-week aerobic exercise plus cognitive restructuring paradigm, or a waitlist control. Both exercise paradigms were found to be effective in reducing anxiety sensitivity compared to the waitlist control (Smits et al., 2008). Interestingly, there was no additive effect found with the inclusion of cognitive restructuring to the exercise paradigm. Smits and colleagues’ results suggest aerobic exercise could be a promising adjunct to psychotherapy for anxiety or a temporary alternative to psychological services (e.g., as a way to manage symptoms in waitlisted individuals).

Research on aerobic exercise as part of a cognitive behavioural therapy intervention has also shown favourable results in reducing levels of the trait in females (Watt, Stewart, Lefaivre, & Uman, 2006). Individuals were randomized to either three hour-long sessions of cognitive behavioural therapy, which included an interoceptive exposure component consisting of running, or to a nonspecific treatment group. In the cognitive behavioural group, females with high anxiety sensitivity (i.e., a score of 27 or more on the ASI) had greater reductions in the trait compared to those with low anxiety sensitivity (i.e., a score of 9 or less). Although findings are consistent with the notion that aerobic exercise is an effective method of providing interoceptive exposure to reduce anxiety sensitivity, it is possible that reductions in the trait were due to other aspects of the treatment.
There are multiple mechanisms through which aerobic exercise may effect reductions in anxiety. Significant physiological changes are not likely to result from short aerobic exercise paradigms such as the ones used in contemporary anxiety sensitivity research. Reductions in anxiety sensitivity through aerobic exercise appear to be a promising avenue of research with important practical implications; however, nonspecific factors, such as behavioural activation and distraction, have been cited as possible confounding factors in this relationship (Broman-Fulks & Storey, 2008; Smits et al., 2008). No study to date has effectively accounted for or ruled out the effect of nonspecific factors in the relationship between aerobic exercise and reductions in anxiety sensitivity. Adequate randomized controlled trials are needed in order to truly assert the effectiveness of aerobic exercise in reducing anxiety sensitivity.

2. Investigation

2.1 Purpose

Despite the initial support for the effectiveness of aerobic exercise paradigms on reducing anxiety sensitivity, the relationship between exercise and anxiety sensitivity remains relatively unexplored. No study to date has investigated reductions in anxiety sensitivity in aerobic exercise paradigms lasting less than 2 weeks. Some data suggest that maximal decreases in anxiety sensitivity follow the first session of aerobic exercise (Broman-Fulks & Storey, 2008); however, whether treatment gains can be maintained without subsequent sessions and for how long remains unknown. Additionally, studies to date (e.g., Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008; Smits, Berry, Rosenfield, et al., 2008) have only attempted reductions in samples with high anxiety sensitivity. It is, therefore, unknown whether individuals with lower levels of anxiety
sensitivity can achieve similar reductions following aerobic exercise. Not all anxiety disorders are characterized by elevated anxiety sensitivity (Taylor, Koch, & McNally, 1992) and, conversely, a significant number of individuals with anxiety disorders do not have high anxiety sensitivity. Given the association between anxiety sensitivity and psychopathology (Olatunji & Wolitzky-Taylor, 2009), determining whether aerobic exercise can effect reductions throughout the anxiety sensitivity spectrum may have broad implications for public health.

Previous studies provide encouraging preliminary support for the effect of aerobic exercise in reducing anxiety sensitivity; however, methodological limitations of the existing research provide avenues for further studies of aerobic exercise in decreasing anxiety sensitivity. First, studies to date have typically measured anxiety sensitivity using the ASI or ASI-R, both of which have had concerns raised over their psychometric properties. Second, the two randomized controlled trials performed to date used either a waitlist control (Smits et al., 2008) or a non-exercise control (i.e., participants filled out measures in person in the laboratory; Broman-Fulks & Storey, 2008); as such, changes in anxiety sensitivity may have been due in part to non-specific factors (e.g., behavioural activation, increase in social engagement) rather than to aerobic exercise specifically. In other words, relative reductions in anxiety sensitivity reported by participants in the aerobic exercise group may have been due to having higher interactions with researchers relative to control group counterparts.

The present trial was designed to add to knowledge on the dose-response relationship between aerobic exercise and anxiety sensitivity by (a) quantifying the effect of a single session of aerobic exercise on anxiety sensitivity, and (b) determining
whether reductions in anxiety sensitivity can be achieved with individuals at varying levels of the trait, as opposed to individuals with high anxiety sensitivity exclusively. In addition, the present trial addressed methodological limitations of previous studies by (a) using a randomized controlled trial design comprised of an aerobic exercise treatment group and a placebo exercise (i.e., stretching) control group, and (b) assessing anxiety sensitivity using a more psychometrically sound measure (i.e., the ASI-3; Taylor et al., 2007) than the one used in previous studies.

2.2 Hypotheses

The current trial tested the following hypotheses:

1. Participants in the aerobic exercise group will show a significant decrease ($p < .05$) in overall anxiety sensitivity, while participants in the control group will not show any statistically significant differences in anxiety sensitivity.

2. Baseline anxiety sensitivity scores will show statistically significant ($p < .05$) association with reductions in anxiety sensitivity at post-treatment.

2.3 Participants

Ethical approval to conduct the trial was obtained through the University of Regina Research Ethics Board. Individuals were recruited from the community as well as the University of Regina Psychology Participant Pool. Individuals were eligible to participate in the trial if they were between 18 and 65 years old and were able to safely engage in physical activity. Individuals who were currently undergoing psychopharmacological treatment were only eligible for the trial if they were on a stable dosage for at least 6 weeks and for the duration of the trial. Individuals taking
benzodiazepines or antipsychotic medication were ineligible for participation in the trial. Once all data had been collected, regression was used to test for outliers in the sample, using participant’s identification number as the dependent variable and the ASI-3 post-treatment change score at the independent variable. Change scores were used because, even though an individual’s baseline and post-treatment scores may be typical for the current sample, a large difference between the two scores suggests inconsistent responding to the measure. The criterion for outliers was set to a Mahalanobis distance $p$-value of less than .001 (Tabachnick & Fidell, 2013). Outliers were removed from the data prior to proceeding with the main analyses. A detailed description of participants is provided in Section 3.1 below.

2.4 Screening Measures

2.4.1 Physical Activity Readiness Questionnaire (PAR-Q; Chisholm, Collis, & Kulak, 1975; See Appendix A). The PAR-Q is a seven-item self-report questionnaire covering physiological symptoms that may limit participants’ readiness to engage in physical activity. The questionnaire covers symptoms such as cardiac problems, chest pain, high blood pressure, dizzy spells, and joint problems. Participants who endorse any item on the PAR-Q were required to complete an additional measure (described below). Data gathered from this measure were used in the pre-treatment online screen only in order to determine participant eligibility.

2.4.2 Physical Activity Readiness Medical Questionnaire (PAR-Med). Participants who meet all eligibility criteria except for the PAR-Q were asked to have their physician complete the PAR-Med to ensure that the participant is able to safely engage in physical exercise and take part in the trial. Participants were ineligible to take
part in the trial if their physician deemed physical activity to be a salient risk. Data
gathered from this measure were used to exclude ineligible participants and was only
used in the pre-treatment phase of the trial.

2.5 Psychological and Lifestyle Measures

2.5.1 Anxiety Sensitivity Index – 3 (ASI-3; Taylor et al., 2007; See Appendix
B). The 18-item ASI-3 was used to assess participants’ fear of arousal-related sensations.
Items are scored on a 5-point Likert scale ranging from 0 (agree very little) to 4 (agree
very much). The ASI-3 measures three dimensions comprising a higher order factor of
anxiety sensitivity, namely Physical Concerns (i.e., fear of somatic sensations),
Cognitive Concerns (i.e., cognitive dyscontrol), and Social Concerns (i.e., fear of
publicly observable symptoms). Subscale and total scores are obtained simply by
summing participants’ responses to corresponding items. The ASI-3 shows good
reliability and validity (Taylor et al., 2007). The measure was used at each data
collection point during the trial. In the present trial, the ASI-3 had good to excellent
internal consistency for total (Cronbach’s $\alpha \geq .94$), Physical Concerns (Cronbach’s $\alpha
\geq .89$), Cognitive Concerns (Cronbach’s $\alpha \geq .94$), and Social Concerns scores
(Cronbach’s $\alpha \geq .87$) at all time points in the present trial.

2.5.2 Healthy Physical Activity Participation Questionnaire (HPAPQ; Gledhill, 2004; See Appendix C). The HPAPQ is a 3-item self-report that assesses
participants’ current level of physical activity. Items measuring frequency and intensity
of physical activity are scored on a 3-point forced-choice answer format. The third item,
which measures participants’ overall perceived fitness, is scored on a 5-point forced-
choice answer format ranging from 0 (very poor) to 4 (very good). The HPAPQ was
used to characterize the present study sample and was only administered to during the pre-treatment online screen. The HPAPQ had acceptable internal consistency in the trial sample, Cronbach’s $\alpha = .74$.

2.5.3 Manipulation check. In order to test for potentially important differences between participants’ perception of the experimental paradigms, participants were asked to answer the following questions:

- How difficult was the exercise session that you just completed? (rated from 0 [not at all difficult] to 10 [extremely difficult])
- How much did you pay attention to the physical sensations (e.g., tightness in your muscles, sweating, changes in your breathing) that were brought on by the exercise session? (rated from 0 [not at all] to 10 [that was all I could think about])
- In comparison to the last time you performed similar exercise, how distressing were the physical sensations (e.g., muscle tightness, difficulty breathing) you experienced during today's exercise session? (rated from 0 [much less distressing] to 10 [much more distressing])
- During exercise, some individuals worry that they may experience negative health consequences (e.g., choking, vomiting, fainting, heart attack). In comparison to times you've completed similar exercise in the past, how safe did you feel exercising in the lab environment today? (rated from 0 [much less safe] to 10 [much safer])
- How much did you enjoy the exercise session you just completed? (rated from 0 [not at all] to 10 [very much]).
2.6 Physiological Measurements

2.6.1 Skinfold measurement. Body fat percentage was estimated using triceps, subscapular, iliac crest, abdominal, chest, and front thigh skinfold measurements. To ensure consistency, the average of two measurements from each area of the body was used in subsequent calculations. Values were summed and inserted into one of the following formulae:

Males aged 18 to 30 years: ([sum of 6 measurements] x 0.10) + 3.64
Males aged 30 years and older: ([sum of 6 measurements] x 0.11) + 4.98
Females aged 18 to 30 years: ([sum of 6 measurements] x 0.22) + 4.47
Females aged 30 years and older: ([sum of 6 measurements] x 0.22) + 2.80

Skinfold measurement was used as a recruitment tool as part of an overall assessment of participants’ level fitness and performance in the in-lab portion of the trial. Research assistants certified in personal training provided feedback regarding body fat percentage and vital signs to participants upon completion of the study. Participants were given the option to forego skinfold measurement and/or certified personal trainer feedback if desired.

2.6.2 Vital signs. Participants’ blood pressure, resting heart rate, and weight were recorded in order to characterise the study sample. A research assistant certified in personal training measured blood pressure and heart rate using an electronic pressure cuff. Participants’ weight was measured in kilograms using a spring scale. Participants’ target heart rate for the aerobic exercise paradigm was determined using the following formula:

Lower bound: 0.60 * [(220–age of participant) – (resting heart rate)]
Upper bound: \(0.80 \times [(220 - \text{age of participant}) - (\text{resting heart rate})]\)

### 2.7 Equipment.

#### 2.7.1 Stationary cycle. Participants performed the exercise phase on a Keiser M3 Series spin cycle. The cycle seat and handle were adjusted according to participants’ physical stature. The cycle’s tension level was adjusted for each participant to in order to reach the desired target heart rate.

#### 2.7.2 Heart rate monitor. Participants wore a Freemotion spinbike console-SMPFMP11 heart rate monitor during each exercise session. To ensure precision and reliability of measurements, the heart rate monitor was worn at the xiphoid process. A research assistant certified in personal training examined heart rate monitor readings during exercise to ensure participants exercised at the desired intensity.

### 2.8 Procedure

The trial was advertised using various methods, including online postings (e.g., kijiji.ca, usedregina.com), posters, and the University of Regina Psychology Participant Pool. The study was promoted as a free exercise session and fitness assessment with a certified personal trainer. Advertisements included a link to an online screening questionnaire and the study email address for more information. Individuals were also informed that the total time commitment was approximately two hours and that, upon completion of the study, they would be provided with feedback from their personal trainer as well as either a 7-day gym membership trial, a discounted 1-month membership trial, or a 50% discount toward additional personal training sessions. Students recruited through the Participation Pool were rewarded with either course credit or with one of the rewards offered to community participants.
A graphical representation of the trial protocol is presented in Figure 1. The trial utilized a randomized control design. Once individuals were deemed eligible for participation in the trial, they were randomized to either the aerobic exercise group or a stretching control group. Consistent with Consolidated Standards of Reporting Trials (CONSORT; Schulz, Altman, & Moher, 2010) guidelines, group assignment was determined by using a randomization plan generator (http://www.randomization.com). Group membership was concealed from both research assistants and participants until just prior to the experimental phase of the trial. Participants were uninformed of the existence of the other group. Participants and research assistants were also unaware of the purpose and hypotheses of the trial.

Trial participation involved five components: (1) online measures and initial phone screen, (2) pre-treatment in-lab testing, (3) aerobic exercise or placebo exercise paradigm, (4) post-treatment psychological measures, and (5) 3-day and 7-day follow-up psychological measures. All participants underwent the same pre-treatment online measures, initial phone screen, post-treatment psychological measures, and follow-up psychological measures. A description of each trial component is provided below.

2.8.1 Online measures and initial phone screen. Individuals interested in participating in the trial were directed to a secure website (www.surveymonkey.com) to provide information such as age, current psychopharmacological treatment, and use of benzodiazepines and antipsychotic medication. Individuals’ answers to these questions were used to determine their eligibility for the trial. Those who met the first round of eligibility criteria were immediately redirected to complete the following online questionnaires: PAR-Q, ASI-3, and HPAPQ. Participants were asked to provide a phone
Online measures and initial phone screen

Pre-treatment in-lab testing and information session
Participant randomization

Aerobic exercise paradigm  Stretching control paradigm

Post-intervention psychological questionnaires

3 day follow-up

1 week follow-up

Time
1 week
1 day
3 days
4 days

Study phase
Baseline
Intervention
Follow-up

Figure 1. Study protocol.
number for contact. Participants who completed the online measures were telephoned for further screening. Individuals who endorsed any item on the PAR-Q were asked to have their doctor complete the PAR-Med before continuing participation. Individuals who meet all eligibility criteria were invited to schedule a time to complete the experimental phase of the trial. During the phone screen, the participants were asked to avoid exercise for 48 hours before participating in the trial and, if possible, to avoid exercise until they completed both follow-up questionnaires. Because anxiety sensitivity has been shown to moderate the relationship between caffeine consumption and the perception of somatic sensations during exercise (Gliottoni & Motl, 2008), participants were also asked to avoid caffeine on the day of their participation. The period of abstinence from caffeine was restricted to less than 12 hours in order to avoid potential withdrawal symptoms (Juliano & Griffiths, 2004). Participants received an email confirming their appointment date after completing the phone screen.

2.8.2 Pre-treatment in-lab testing and information session. Participants were greeted by a member of the research team upon arrival to the laboratory and directed to the locker room to change into appropriate workout attire if needed. A research assistant certified in personal training completed the physical testing before the experimental phase, including skinfold measurement, weight, and blood pressure. The same research assistant then guided participants through the control or aerobic exercise paradigm, as determined by the randomization procedure. All participants completed their assigned paradigm individually with the research assistant.

2.8.3 Aerobic exercise paradigm. The current trial utilized an exercise paradigm similar to one used in previous literature (Broman-Fulks & Storey, 2008;
Smits et al., 2008), albeit in an abbreviated form. Participants’ heart rate was monitored during the exercise phase and they were asked to either increase or reduce the intensity of exercise if needed in order to maintain the appropriate exertion rate. Participants underwent a 5-minute warm-up (i.e., 2 minutes and 30 seconds at little or no resistance followed by 2 minutes and 30 seconds at increasing resistance until the minimum target heart rate was reached). They subsequently completed a 10-minute pyramid (i.e., increased resistance every minute for 5 minutes, followed by decreased resistance every minute for another 5 minutes), a 10-minute sprint (i.e., 30 seconds of increased resistance, followed by 30 seconds of recovery at lower speed and resistance), and a 5-minute cool-down at little to no resistance.

2.8.4 Stretching control paradigm. Participants in the control group underwent a stretching paradigm consisting of 36 stretches held for 45 seconds, including 3 minutes allowed for transitioning between poses. Although, as noted above, contemporary research on aerobic exercise and anxiety sensitivity has yet to use placebo controls, research on individuals with mild to moderate major depressive disorder suggests a stretching control has similar effects to placebo (Dunn, Trivedi, Kampert, Clark, & Chambliss, 2005). The stretching paradigm was expected to have a similar effect on anxiety sensitivity in the present trial. Stretching bears resemblance to yoga, which has been shown to reduce anxiety (Field et al., 2010; Streeter et al., 2007); however, the stretching paradigm was believed to differ significantly from yoga because it did not involve postures readily associated with the practice (e.g., warrior, tree, and prayer positions), breathing exercises, or salutations. Participants’ heart rate was monitored
during the procedure to ensure that it remained below 50% of their maximum heart rate reserve.

2.8.5 Post-treatment and follow-up psychological testing. Immediately following the intervention phase, participants completed the ASI-3. Participants were sent automated emails asking them to complete the same questionnaire on two subsequent occasions, including once at 3 days and once at 7 days post-treatment. Participants were asked to complete the questionnaire within 24 hours of receiving the automated email. At each time point, participants were also asked to report how many times they had engaged in moderate to intense exercise since they last filled out the questionnaires.

2.9 Analyses

2.9.1 Hypothesis 1. To test Hypothesis 1, data analyses involved two-level hierarchical linear modeling to determine the relationship between experimental group (i.e., aerobic exercise and stretching control) and anxiety sensitivity at baseline, post-intervention, and follow-up. Hierarchical linear modeling is advantageous for use in randomized controlled trials because it maximizes statistical power (Shin, 2009) and deals well with missing data or data collected at irregular intervals (Tabachnick & Fidell, 2013). Multiple imputation for missing data and intent-to-treat analyses were not conducted in the present sample because hierarchical linear models can effectively tolerate missing data in repeated measures designs (Tabachnick & Fidell, 2013). The statistical power of hierarchical modeling is not easily predicted because it depends on the interaction of many factors, such as compliance with specific assumptions (Kreft & DeLeeuw, 1998). Therefore, the present trial aimed for a sample size similar to that used
in contemporary literature utilizing hierarchical linear modeling (i.e., approximately 20 individuals per group, totalling 40 participants; Smits et al., 2008). Predicting an attrition rate of approximately 20%, similar to previous studies in the field (Smits et al., 2008), resulted in a recruitment target of 50 participants. Contemporary literature suggests that the effect of exercise on anxiety sensitivity does not significant vary by sex (Smits et al., 2008). The estimated sample size was therefore not adjustment to account for sex differences.

Separate sets of hierarchical linear model analyses were performed for each of the primary outcome variables in the trial, namely ASI-3 total, ASI-3 Cognitive Concerns, ASI-3 Social Concerns, and ASI-3 Physical Concerns. The primary predictor variables in the analyses were time and experimental group (i.e., aerobic exercise vs. stretching control). Each set of analyses began by testing for an effect of time, experimental group, and time by experimental group interaction on the outcome variable. Significant time by experimental group interactions were further investigated by conducting separate analyses for each group. These group-specific models included only time as a predictor. The time variable was coded chronologically beginning at -1 (baseline) and with the intercept (0) corresponding to post-treatment. Because follow-up data were time-unstructured (i.e., the observations were unevenly spaced across individuals because of delays in filling out follow-up questionnaires), the two follow-up time points were coded as the number of days since post-treatment. This time variable was treated as continuous and was used to estimate the daily change in anxiety sensitivity following the intervention. A categorical dummy time variable, the values of which corresponded to each measurement occasion, was used to test for differences in
anxiety sensitivity scores between measurement occasions. Because post-treatment scores generally did not differ from baseline, post-treatment scores were used as a more accurate measure of anxiety sensitivity for pairwise comparisons, as the number of days between post-treatment and follow-up was typically shorter and less variable than the number of days between baseline and follow-up.

Clinically significant change in ASI-3 Total scores was also assessed in each experimental group using the recommendations of Jacobson and Truax (1991). Clinical significance can be quantified as a change in scores of more than 2 standard deviations (Jacobson & Truax, 1991). Using norms provided by Taylor and colleagues (2007), a reduction of at least 21 points on the ASI-3 would meet this criterion. Because this magnitude of change is too stringent to quantify change in individuals scoring less than 21 on the ASI-3, the criterion was relaxed to 1 standard deviation, representing a magnitude of change of at least 11 points. This more liberal definition of clinically significant change has been used previously in the literature (Broman-Fulks et al., 2004). Additionally, a difference of 1 standard deviation above the mean is frequently used as a cut-off score for high anxiety sensitivity (Sabourin et al., 2008; Sabourin, Hilchey, Lefaivre, Watt, & Stewart, 2011; Smits et al., 2008; Watt, Stewart, Birch, & Bernier, 2006; Watt, Stewart, Lefaivre, et al., 2006). The percentage of individuals who showed clinically significant change was calculated at each time point, based on the total number of participants who completed the ASI-3 and had a baseline ASI-3 Total score of at least 11 points within the same experimental group.

The sample size in the current trial was insufficient to test for some covariates of potential interest, such as exercise frequency after the intervention. Independent samples
t-tests were conducted as ancillary analyses to determine whether there were any group differences in exercise frequency at either of the follow-up points. Differences in exercise frequency at follow-up could confound the results of the hierarchical linear models and, as such, the t-tests were computed in order to rule out this possibility. In addition, t-tests were conducted to test for the manipulation check questions to determine whether any other confounding factors could be responsible for group differences in anxiety sensitivity after the intervention.

2.9.2 Hypothesis 2. Hypothesis 2 was tested by examining the variance in intercepts, the variance in slopes, and the covariance between intercepts in slopes for ASI-3 Total scores in the hierarchical linear model. This information was obtained by modifying the random parameters of the model. First, a random intercept between individuals was specified, and then a random slope, and finally the covariance between intercept and slope. At each step, the significance of each parameter was tested by examining the change in -2 log likelihood (-2LL), which is a measure of model fit (Field, 2013). The -2LL follows a chi-square distribution with degrees of freedom corresponding to the change in the number of parameters between the original model and the model to which the new random parameter was added. A non-significant reduction in -2LL after adding the covariance between intercept and slope parameter would suggest that the magnitude of change in ASI-3 Total scores is approximately the same for all individuals, regardless of their baseline score. These tests were conducted solely in models that included a significant main effect of time.
3. Results

3.1 Participant Characteristics

An overview of participant flow in the study is provided in Figure 2. Of the 101 individuals who showed interest in the study by initiating the online screening questionnaire, 41 met all eligibility criteria and participated in the in-lab portion of the trial. Data from one participant were omitted from the analyses because the ASI-3 change score at post-treatment had a significant Mahalanobis distance of 14.934 ($p < .001$; Tabachnick & Fidell, 2013). Of the 40 participants analyzed, 34 (85.0%) completed the first follow-up and 31 (77.5%) completed the second follow-up. Four individuals filled out neither of the follow-ups. The level of attrition was similar to other research in this area (Smits et al., 2008). A detailed description of participant flow is provided in Figure 2. Follow-up data points were removed if participants filled out the 3-day follow-up questionnaire more than 4 days after post-treatment or if they filled out the 7-day follow-up questionnaire more than 9 days after post-treatment. Follow-up data points were separated by at least 2 days. After removing data from participants who were off schedule, there remained 27 participants (67.5%) who completed the first follow-up and 24 participants (60.0%) who completed the second follow-up in a timely fashion. There were no differences in the level of attrition in the control group and the aerobic exercise group. Cross tabulations using Fisher’s exact test revealed both groups were equally likely to complete the 3-day follow-up ($p = .091$), the 7-day follow-up ($p = .051$), and at least one of the two follow-ups ($p = .060$). Hierarchical linear modelling requires a minimum of two data points for each case (e.g., baseline and post-treatment);
Figure 2. Participant flow.
therefore, all participants were analyzed regardless of whether they completed both follow-up questionnaires.

The range of scores on the ASI-3 was 0 to 49 in the aerobic exercise group and 0 to 50 in the control group. Scores on the ASI-3 were slightly skewed at baseline (skewness = 1.12, SE = 0.37), post-treatment (skewness = 0.88, SE = 0.37), and 7-day follow-up (skewness = 1.12, SE = 0.47), but not at 3-day follow-up (skewness = 0.46, SE = 0.45). There were no problems with kurtosis at baseline (kurtosis = 0.81, SE = 0.73), post-treatment (kurtosis = 0.05, SE = 0.73), 3-day follow-up (kurtosis = -0.98, SE = 0.87), or 7-day follow-up (kurtosis = 0.65, SE = 0.92).

Individuals in both groups were similar in terms of age, ethnicity, employment status, anxiety sensitivity, self-rated fitness, and pre-treatment exercise frequency (see Table 1). There was a greater proportion of females and individuals who completed university-level education in the control group compared to the aerobic exercise group. Consistent with CONSORT guidelines, hypothesis testing for differences between experimental groups was not conducted because randomly assigning individuals assures that any group differences are due to chance (Schulz et al., 2010).

3.2 Hypothesis 1

Mean ASI-3 Total scores for the aerobic exercise and control groups are presented in Table 2 and in Figure 3. The results of the hierarchical linear model revealed no significant effect of experimental group on anxiety sensitivity, \( p = .334, \) one-tailed, \( d = 0.14 \); however, there was an effect of time \( p < .001, \) two-tailed, \( d = 1.37 \) and a group by time interaction \( p < .001, \) two-tailed, \( d = 1.30 \). For the aerobic exercise group specifically, there was a significant effect of time on anxiety sensitivity
Table 1. Participant characteristics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Aerobic exercise group (n = 21)</th>
<th>Control group (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Age</td>
<td>35.33</td>
<td>13.30</td>
</tr>
<tr>
<td>ASI-3 Total</td>
<td>17.52</td>
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<tr>
<td>ASI-3 Cognitive</td>
<td>3.57</td>
<td>4.64</td>
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<td>ASI-3 Social Concerns</td>
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<td>5.30</td>
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<tr>
<td>Sex</td>
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<td></td>
</tr>
<tr>
<td>Male</td>
<td>10</td>
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<tr>
<td>Female</td>
<td>11</td>
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</tr>
<tr>
<td>Ethnicity</td>
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<tr>
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<tr>
<td>Pacific Islander</td>
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</tr>
<tr>
<td>Asian</td>
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<td>0.0</td>
</tr>
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<td>High school</td>
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<tr>
<td>Some college</td>
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<td>Employment</td>
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<td>Full time</td>
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<td>Part time</td>
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<td>Student</td>
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<td>19.0</td>
</tr>
<tr>
<td>Not employed</td>
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<td>4.8</td>
</tr>
<tr>
<td>Declined to answer</td>
<td>2</td>
<td>9.5</td>
</tr>
<tr>
<td>Self-rated fitness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very poor</td>
<td>4</td>
<td>19.0</td>
</tr>
<tr>
<td>Poor</td>
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<td>19.0</td>
</tr>
<tr>
<td>Average</td>
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<tr>
<td>Good</td>
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<tr>
<td>Very good</td>
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<td>4.8</td>
</tr>
<tr>
<td>Exercise Frequency</td>
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<tr>
<td>Less than once a week</td>
<td>6</td>
<td>28.6</td>
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<tr>
<td>1 to 2 times a week</td>
<td>9</td>
<td>42.9</td>
</tr>
<tr>
<td>3 or more times a week</td>
<td>6</td>
<td>28.6</td>
</tr>
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</table>

*Note. ASI-3 = Anxiety Sensitivity Index-3.*
Table 2. Anxiety sensitivity scores at baseline, post-treatment, and follow-up.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Aerobic exercise group</th>
<th></th>
<th>Control group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>ASI-3 Total</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>17.52</td>
<td>13.03</td>
<td>13.47*</td>
<td>12.82</td>
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<tr>
<td>Post-treatment</td>
<td>17.90</td>
<td>13.91</td>
<td>16.68</td>
<td>13.52</td>
</tr>
<tr>
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<td>16.06 **</td>
<td>14.21</td>
<td>20.30</td>
<td>14.36</td>
</tr>
<tr>
<td>Second follow-up</td>
<td>11.56 ***a</td>
<td>12.51</td>
<td>17.25</td>
<td>14.05</td>
</tr>
<tr>
<td>ASI-3 Cognitive Concerns</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>3.53</td>
<td>4.59</td>
</tr>
<tr>
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<td>4.63</td>
<td>4.16</td>
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</tr>
<tr>
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<td>3.65 **</td>
<td>4.49</td>
<td>6.20</td>
<td>5.51</td>
</tr>
<tr>
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<td>4.06</td>
<td>5.50</td>
<td>5.90</td>
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<tr>
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<td></td>
<td></td>
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<td></td>
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<tr>
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<td>8.71</td>
<td>5.83</td>
<td>6.58 **</td>
<td>5.70</td>
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<tr>
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<tr>
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<td>7.35 *</td>
<td>6.64</td>
<td>9.10</td>
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<td>ASI-3 Physical Concerns</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>5.24</td>
<td>5.30</td>
<td>3.37</td>
<td>3.80</td>
</tr>
<tr>
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<td>5.44</td>
<td>3.42</td>
<td>3.83</td>
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<tr>
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<td>5.51</td>
<td>5.00</td>
<td>4.45</td>
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<tr>
<td>Second follow-up</td>
<td>2.63 **†</td>
<td>3.83</td>
<td>2.88</td>
<td>4.29</td>
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</tbody>
</table>

*Note. ASI-3 = Anxiety Sensitivity Index-3. Asterisks denote significant differences in means compared to post-treatment, *p < .05, **p < .01, ***p < .001. Total and Social Concerns scores increased from baseline to post-treatment in the control group. Daggers denote significant differences in means between first and second follow-up, †p < .05. Probabilities for the aerobic exercise group are one-tailed. *Difference in means compared to first follow-up approached significance, .10 > p > .05.
Figure 3. ASI-3 Total scores before, during, and after the intervention.
(p < .001, d = 1.84), with an average decrease in anxiety sensitivity of approximately 0.71 points per day following the intervention. Compared to post-treatment, the difference in anxiety sensitivity at baseline was not significant (p = .379, one-tailed, d = 0.07), and scores were significantly lower at first follow-up (p = .004, one-tailed, d = 0.32) and at second follow-up (p < .001, one-tailed, d = 0.97). There was an average decrease of 3.64 points between post-treatment and first follow-up, and an average decrease of 5.90 points between post-treatment and second follow-up. The decrease in scores from first follow-up to second follow-up approached significance (p = .051, one-tailed, d = 1.33). For the control group, the effect of time approached significance (p = .064, two-tailed, d = 0.90). There was an average increase of 3.23 points from baseline to post-treatment (p = .048, two-tailed, d = 0.48), but there were no significant differences between post-treatment and first follow-up (p = .652, two-tailed, d = 0.67) or second follow-up (p = .403, two-tailed, d = 0.10).

Mean ASI-3 Cognitive Concerns scores for the aerobic exercise and control groups are presented in Table 2 and in Figure 4. Overall, there was no significant effect of group (p = .446, one-tailed, d = 0.04), although there was a significant effect of time (p = .036, two-tailed, d = 0.64), and a significant group by time interaction (p = .001, d = 1.05). For the aerobic exercise group, there was a significant effect of time (p = .003, one-tailed, d = 0.98), with an average decrease of 0.13 points per day following the intervention. Compared to post-treatment, there was no significant difference in scores at baseline (p = .037, one-tailed, wrong direction, d = 0.39), although there was a significant decrease at first follow-up (p = .002, d = 0.42) and second follow-up (p = .002, d = 0.74). There was an average decrease of 1.41 points between post-treatment
Figure 4. ASI-3 Cognitive scores before, during, and after the intervention.
and first follow-up, and an average decrease of 1.42 points between post-treatment and follow-up. The difference in scores between first follow-up and second follow-up was not significant ($p = .494$, one-tailed, $d = 0.72$), which was likely due to the magnitude of the standard error for the difference in scores. For the control group, there was a significant effect of time ($p = .041$, two-tailed, $d = 1.08$), with an average increase in scores of 0.26 points per day following the intervention. Compared to post-treatment, there were no significant differences from baseline ($p = .384$, one-tailed, $d = 0.22$) or at first follow-up ($p = .286$, $d = 0.64$), although there was a marginally significant increase of 1.85 points at second follow-up ($p = .082$, $d = 0.46$).

Mean ASI-3 Social Concerns scores for the aerobic exercise and control groups are presented in Table 2 and in Figure 5. The results of the hierarchical linear model revealed no significant effect of group ($p = .409$, one-tailed, $d = 0.09$); but, there was an effect of time ($p < .001$, two-tailed, $d = 1.05$) and a group by time interaction ($p < .001$, two-tailed, $d = 1.00$). For the aerobic exercise group, there was a significant effect of time ($p = .001$, one-tailed, $d = 1.87$), with an average decrease of 0.31 points per day following the intervention. Compared to post-treatment, there was no significant difference in scores at baseline ($p = .471$, one-tailed, $d = 0.01$), although there was a significant decrease at first follow-up ($p = .021$, one-tailed, $d = 0.51$) and second follow-up ($p = .001$, one-tailed, $d = 0.74$). There was an average decrease of 1.60 points between post-treatment and first follow-up, and an average decrease of 2.44 points between post-treatment and second follow-up. The difference in scores between first follow-up and second follow-up approached significance ($p = .149$, one-tailed, $d = 0.67$). For the control group, there was no significant effect of time ($p = .083$, two-tailed, $d =
Figure 5. ASI-3 Social scores before, during, and after the intervention.
0.87). When comparing measurement occasions, individuals scored on average 2.53 points higher at post-treatment compared to baseline ($p = .003$, two-tailed, $d = 0.75$); but, there were no differences between post-treatment and first-follow-up ($p = .562$, two-tailed, $d < 0.01$) or second follow-up ($p = .847$, two-tailed, $d = 0.09$).

Mean ASI-3 Physical Concerns scores for the aerobic exercise and control groups are presented in Table 2 and in Figure 6. Overall, there was no significant effect of group ($p = .152$, one-tailed, $d = 0.33$), although there was a significant effect of time ($p = .001$, two-tailed, $d = 1.18$) and a significant group by time interaction ($p = .050$, two-tailed, $d = 0.65$). For the aerobic exercise group, there was a significant effect of time ($p = .003$, one-tailed, $d = 0.98$), with an average decrease of 0.13 points per day following the intervention. Compared to post-treatment, there was no significant difference in scores at baseline ($p = .189$, one-tailed, $d = 0.20$) or first follow-up ($p = .273$, one-tailed, $d = 0.08$), although there was a significant average decrease of 1.87 points at second follow-up ($p = .007$, one-tailed, $d = 0.79$). There was a significant decrease of 1.51 points from first follow-up to second follow-up ($p = .023$, one-tailed, $d = 1.59$). For the control group, there was no significant effect of time ($p = .838$, two-tailed, $d = 0.09$). Compared to post-treatment, there was no significant difference in scores at baseline ($p = .905$, two-tailed, $d = 0.02$), first follow-up ($p = .337$, two-tailed, $d = 0.94$), or second follow-up ($p = .630$, two-tailed, $d = 0.25$).

Clinically significant change was observed in one individual (10.0%) at post-treatment, one individual (14.3%) at 3-day follow-up, and four individuals (50.0%) at 7-day follow-up in the aerobic exercise group. An additional two individuals in this group had decreases in anxiety sensitivity that approached clinical significance (10 points) at 3-
Figure 6. ASI-3 Physical scores before, during, and after the intervention.
day and 7-day follow-up. None of the participants in the control group had decreases in anxiety sensitivity that were clinically significant or approached clinical significance.

Independent samples $t$-tests suggested there were no differences in exercise frequency between groups at follow-up. In both cases, homogeneity of variance was assumed (Levene’s $p = .997$ and $.093$, respectively). The mean difference in exercise frequency between the aerobic exercise group and the control group did not reach significance at first follow-up ($t[38] = -0.26, p = .795, d = 0.08$) or at second follow-up ($t[38] = -1.02, p = .313, d = 0.34$). These results suggest that the different patterns of change in anxiety sensitivity in the aerobic exercise and control groups were not due to differences in physical activity. For the manipulation check questions, equal variances were also assumed (all Levene’s $ps = .202$). There were no significant differences between groups in attention to physical sensations ($t[38] = 0.17, p = .870$), distress ($t[38] = 0.86, p = .396$), safety ($t[38] = 0.40, p = .693$), and enjoyment ($t[38] = 0.15, p = .148$); but, as expected, the aerobic exercise group rated the session as significantly more difficult than the control group ($t[38] = 4.38, p < .001$).

### 3.3 Hypothesis 2

Because there was no significant effect of time both the overall trial sample and for the control group, analyses were conducted solely in the aerobic exercise group. The random parameters of the model suggested there was significant variance in intercepts between individuals (Var[$u_{0j}$] = 156.88, $\chi^2[1] = 108.03, p < .001$) but no significant variance in slopes (Var[$u_{1j}$] = 0.17, $\chi^2[1] = 1.41, p = .234$) and no significant covariance between intercepts and slopes (Cov[$u_{0j}, u_{1j}$] = 0.58, $\chi^2[1] = 0.06, p = .800$). These results suggest that the magnitude of reduction in anxiety sensitivity after aerobic exercise was
approximately the same for all individuals, regardless of their levels of anxiety sensitivity at baseline.

4. Discussion

The present trial was designed to investigate whether a short bout of aerobic exercise can effect changes in anxiety sensitivity compared to a placebo stretching control, and to determine whether reductions in anxiety sensitivity can be achieved with individuals at varying levels of the trait, as opposed to individuals with high anxiety sensitivity exclusively. The results bolster support for aerobic exercise as a simple and effective method to effect short-term reductions in anxiety sensitivity and suggest that the intervention can be effective in a wider population than previously studied.

While the results of the present trial are promising, they contrast with previous research suggesting that aerobic exercise is associated with an immediate change in the trait that is maintained through subsequent exercise sessions (Broman-Fulks & Storey, 2008). In the present trial, individuals in the aerobic exercise group did not experience reductions in anxiety sensitivity immediately after exercise; however, significant reductions were observed in ASI-3 Total, Cognitive Concerns, and Social Concerns at 3-day follow-up and in all four ASI-3 dimensions at 7-day follow-up. Two reasons could explain these differing results. First, individuals taking part in a longer, 2-week aerobic exercise program may have greater expectations for improvement in their health and mental status. Therefore, they may have been more likely to report changes in anxiety sensitivity immediately after the first session. In the present trial, individuals were only engaging in a single session of exercise and they may have expected to receive fewer benefits from participation as a result. Second, even though individuals in the aerobic
exercise group completed the ASI-3 after a 5-minute physical cool-down, they may have still been experiencing some level of arousal that only dissipated some time after filling out the questionnaires. Although this trial followed an exercise paradigm similar to the Broman-Fulks and Storey study, there may have been differences in time between the end of the exercise session and the completion of the questionnaires. Reductions in anxiety sensitivity from post-treatment to first follow-up were either maintained or increased in magnitude at second follow-up and represented medium to large effect sizes. These results suggest that although the benefits are not immediate, they take effect relatively quickly and are maintained for at least one week. Although direct comparisons of effect sizes with previous studies in the area (i.e., Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008; Smits et al., 2008) are not possible due to differences in statistical analyses and methodology, the results of the present trial are at least consistent in suggesting statistically moderate to large effects of aerobic exercise in reducing anxiety sensitivity.

As predicted, the control group did not experience any decrease in anxiety sensitivity at post-treatment or at follow-up. Interestingly, there was an increase in ASI-3 Total and Social Concerns at post-treatment compared to baseline. The increase in ASI-3 Total was due solely to an increase in Social Concerns at post-treatment; indeed, individuals did not show any change in the cognitive and physical dimensions of anxiety sensitivity. The control condition involved a number of standing, sitting, and laying positions that are more technically complex than cycling. It is possible that individuals in this group felt more self-conscious about their performance in front of the research assistant, either because they had difficulty getting into position or because they felt a
greater focus on their physical appearance when performing the stretches.

Notwithstanding, the relative stability of anxiety sensitivity dimensions in the stretching condition suggests that the paradigm could be effectively used as a placebo control in further studies if some modifications are made to minimize social concerns. Such modifications could include modifying or removing poses that are associated with self-consciousness or social discomfort or simplifying the stretching paradigm in order to eliminate the need for direct supervision from a research assistant.

The sample in the present trial included individuals with a wide range of anxiety sensitivity and the results suggest that one bout of aerobic exercise is effective in reducing anxiety sensitivity across the continuum of the trait. Clinically significant change was observed in a large portion of individuals in the aerobic exercise group, but it was not observed in any individuals in the control group, lending further support to the effectiveness of the intervention. Additionally, the magnitude of reduction in anxiety sensitivity after aerobic exercise was unrelated to individuals’ baseline levels of the trait. In other words, all individuals appeared to benefit equally from the intervention. These results provide a foundation for expanding the use of aerobic exercise as a way to reduce anxiety sensitivity in a wide range of individuals. The results are also consistent with a dimensional, rather than categorical, characterisation of anxiety sensitivity (Asmundson et al., 2011). Rather than being applicable only to individuals with “high” levels of the trait, the use of aerobic exercise could be expanded to individuals for whom fear of arousal sensations causes distress, even though they may not meet the cutoff scores typically used to define “high” anxiety sensitivity.
The results of the present trial support the hypothesis that reductions in anxiety sensitivity following aerobic exercise are due to interoceptive exposure and not increased social engagement or other nonspecific factors. If reductions in anxiety sensitivity were due to social engagement (e.g., though increased contact with researchers) or some other nonspecific factor (e.g., behavioural activation or distraction from daily stresses), individuals in both the exercise and control groups would have been expected to experience reductions in the trait. In the present trial, only the exercise condition was associated with reductions in anxiety sensitivity. The difference in the pattern of change in anxiety sensitivity in both conditions also did not appear to be due to differences in attention to physical sensations, level of distress during the session, perceived safety of the experimental paradigm, or enjoyment. Therefore, it is unlikely that aerobic exercise yielded different results because of individuals’ perception of the task they were performing. The aerobic exercise group did, however, rate the experimental paradigm as significantly more difficult than the control group. Arguably, aerobic exercise was a more effective form of interoceptive exposure and thus was associated with decreased anxiety sensitivity; however, the exact mechanism of action of interoceptive exposure in the present trial remains unclear. Several models for the effectiveness of interoceptive exposure have been suggested, including conditioning, cognitive restructuring, emotional processing, social learning, and acceptance (Stewart & Watt, 2008). While the present trial was not specifically designed to investigate these mechanisms, the results lend greater support to some, but not to others. It is unlikely that conditioning lead to decreases in anxiety sensitivity, as the trial only involved one session and exposure was not repeated. Acceptance of negative emotional states,
although not impossible, is likely to require more than one exposure. Because reductions in anxiety sensitivity in the aerobic exercise group were not immediate and in some cases increased in magnitude over the following week, some form of cognitive or emotional processing may have been involved. In the days following participation, or when completing follow-up questionnaires, individuals may have thought back on their experience in the trial, which may have triggered a change in their perspective on anxiety related sensations. As suggested by the social learning model, such a change in perspective could include a greater sense of self-efficacy in dealing with feared bodily sensations.

The results of the present trial also provide greater insight into the dose-response relationship between aerobic exercise and anxiety sensitivity. A single bout of aerobic exercise is effective in reducing total anxiety sensitivity and its three dimensions in the short term, compared to a stretching control. These reductions do not appear to be due to subsequent exercise after participation in the study because individuals in both groups did not differ in exercise frequency at either of the follow-up points. Moderate-to-vigorous physical activity, such as the exercise paradigm in the present trial, can bring about positive short-term changes in mental status, even at a dose less than is typically recommended to reap health benefits. Aerobic exercise can, therefore, be an accessible intervention that quickly provides positive reinforcement in the form of reduced anxiety sensitivity. This type of reinforcement could possibly encourage individuals to sustain exercise in order to obtain other long-term physical and mental health benefits.

Despite being promising, the trial is not without its limitations. First, participants in the trial were not representative of the general population. Although the majority of
participants in the study were from the community, many individuals were students at the University of Regina. The trial population was relatively uniform in demographics such as age, ethnicity, and education. Additionally, the two groups in the trial appeared to differ in terms of sex and education level. Research on the ASI suggests that females have greater physical concerns and overall anxiety sensitivity than males (Stewart, Taylor, & Baker, 1997); however, these differences have not been observed in the ASI-3 (Osman et al., 2010). In the context of aerobic exercise, there is evidence that the intervention is equally effective in reducing anxiety sensitivity in both sexes (Smits et al., 2008). Some researchers have focused on sex-specific relationships between exercise and anxiety sensitivity (e.g., Sabourin et al., 2008, 2011; Watt, Stewart, Lefaivre, et al., 2006); however, there is little research focusing explicitly on sex differences. As such future research should seek to replicate the results with a focus on examining potential sex differences. In addition, consideration should be given to study the effect of aerobic exercise in a more diverse population to determine whether other demographic variables, such as education, moderate the relationship between aerobic exercise and reductions in anxiety sensitivity. Second, the trial assessed changes in anxiety sensitivity within a largely non-clinical sample of individuals; accordingly, it is not possible to determine whether treatment gains are generalizable to individuals with psychopathology. Third, although the sample size was enough to power simple hierarchical linear models, it was insufficient to test covariates of potential interest (e.g., self-rated fitness, exercise frequency).

The relationship between exercise and anxiety sensitivity fuels a promising area of research. Knowledge in the area is quickly growing but many avenues of research
remain to be explored. Research is needed in order to determine the type, intensity, duration, and frequency of exercise that provides optimal benefits while still remaining palatable. Other popular forms of exercise, such as resistance training and yoga appear to be effective in reducing anxiety (Asmundson et al., 2013), but their effects on anxiety sensitivity remain to be investigated. Although resistance training may not cause increased heart rate to the same extent as aerobic exercise, it can still cause anxiety-related sensations (e.g., muscle tightness, sweating) and therefore it could be an effective means of exposure to these sensations. Yoga may also provide some milder form of exposure and its mindfulness component is another avenue or research that could be worthy of attention. Previous studies on the effect of aerobic exercise on anxiety sensitivity, including the present trial, utilized similar 20-minute exercise paradigms at an intensity ranging from 60-90% of maximal heart rate (Broman-Fulks et al., 2004; Broman-Fulks & Storey, 2008; Smits et al., 2008). Future research should seek to determine whether there is an interaction between the intensity and duration of exercise in reducing anxiety sensitivity. It is possible that longer bouts of less intense exercise could be equivalent to shorter bouts of highly intense exercise. Quantifying the relationship between exercise frequency and duration to reduce anxiety sensitivity could ultimately allow greater flexibility in choosing an exercise regimen that maximized individual adherence in order to reduce anxiety sensitivity. Finally, the present trial suggested that very little exercise is required to reduce anxiety sensitivity. Further research on this topic could help clinicians titrate the amount of exercise needed to achieve adequate reductions in anxiety sensitivity according to individuals’ level of the trait.
The present trial is the first to examine the effects of a single bout of aerobic exercise and the first to use a placebo control group. The results of add to current knowledge regarding the dose-response relationship between aerobic exercise and reductions in anxiety sensitivity and bolster the body of evidence for exercise as an effective and empirically-based intervention capable of effecting clinically significant change in anxiety sensitivity. The ability of a single session of exercise to effect short-term reductions in anxiety sensitivity can have important treatment implications. Aerobic exercise may be used as a temporary alternative when psychological services are not immediately available; for example, as a means to manage anxiety symptoms in individuals waitlisted for access to a psychologist. Reductions in anxiety sensitivity have also been suggested as a mechanism of change in cognitive behavioural therapy (Gallagher et al., 2013). Aerobic exercise could be used as an adjunct to psychotherapy in order to complement or enhance its effectiveness. Finally, the results of the present trial have broad implications for public policy. Individuals quickly reaped benefits from aerobic exercise, which for some were clinically significant. The present trial provides evidence that aerobic exercise can have positive psychological effects, even at a dose much lower than is typically recommended by government institutions (Public Health Agency of Canada, 2012; Statistics Canada, 2013), highlighting the fact that a single session of aerobic exercise can effect reductions in anxiety sensitivity could be used to coach individuals into continuing their exercise regimen so that they can achieve even greater reductions in anxiety sensitivity and ultimately reap other mental and physical health benefits.
5. References


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6. Appendices

Appendix A: Physical Activity Readiness Questionnaire

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active everyday. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active. If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age and you are not used to being very active, check with your doctor. Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
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<tbody>
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<td>☐</td>
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Appendix B: Anxiety Sensitivity Index

Please check the number that best corresponds to how much you agree with each item. If any items concern something that you have never experienced (e.g., fainting in public), then answer on the basis of how you think you might feel if you had such an experience. Otherwise, answer all items on the basis of your own experience. Be careful to circle only one number for each item and please answer all items.

<table>
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<th>A little</th>
<th>Some</th>
<th>Much</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
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<td>1.</td>
<td>It is important for me not to appear nervous.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>When I cannot keep my mind on a task, I worry that I might be going crazy.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>It scares me when my heart beats rapidly.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>When my stomach is upset, I worry that I might be seriously ill.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>It scares me when I am unable to keep my mind on a task.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6.</td>
<td>When I tremble in the presence of others, I fear what people might think of me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>7.</td>
<td>When my chest feels tight, I get scared that I won’t be able to breathe properly.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>8.</td>
<td>When I feel pain in my chest, I worry that I’m going to have a heart attack.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>9.</td>
<td>I worry that other people will notice my anxiety.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>10.</td>
<td>When I feel “spacey” or spaced out I worry that I may be mentally ill.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>11.</td>
<td>It scares me when I blush in front of people.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>12.</td>
<td>When I notice my heart skipping a beat, I worry that there is something seriously wrong with me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>13.</td>
<td>When I begin to sweat in a social situation, I fear people will think negatively of me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>14.</td>
<td>When my thoughts seem to speed up, I worry that I might be going crazy.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>15.</td>
<td>When my throat feels tight, I worry that I could choke to death.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>16.</td>
<td>When I have trouble thinking clearly, I worry that there is something wrong with me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>17.</td>
<td>I think it would be horrible for me to faint in public.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>18.</td>
<td>When my mind goes blank, I worry there is something terribly wrong with me.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
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</table>
Appendix C: Healthy Physical Activity Participation Questionnaire

1. Over a typical 7-day period (one week), how many times do you engage in physical activity that is sufficiently prolonged and intense to cause sweating and a rapid heartbeat?
   - At least three times
   - Normally once or twice
   - Rarely or never

2. When you engage in physical activity, do you have the impression that you:
   - Make an intense effort
   - Make a moderate effort
   - Make a light effort

3. In a general fashion, would you say that your current physical fitness is:
   - Very good
   - Good
   - Average
   - Poor
   - Very poor
Appendix D: Research Ethics Board Approval Form

**Certificate of Amendment Approval**

<table>
<thead>
<tr>
<th>PRINCIPAL INVESTIGATOR</th>
<th>DEPARTMENT</th>
<th>REB#</th>
</tr>
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<tr>
<td>Matthew Fetzner</td>
<td>Psychology</td>
<td>02S1213</td>
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**SUPERVISOR**

Dr. Gordon J. G. Asmundson - Psychology

**TITLE**

Investigating the Anxiolytic Effects of Aerobic Exercise for the Treatment of Posttraumatic Stress Disorder Symptoms

<table>
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<th>AMENDMENT APPROVAL OF</th>
<th>ORIGINAL DATE of APPROVAL</th>
<th>CURRENT EXPIRY DATE</th>
<th>Date of Amendment Approval</th>
</tr>
</thead>
<tbody>
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<td>Collect similar data from a community and student sample control group: Appendix C - Intolerance of Uncertainty Scale – Short Form</td>
<td>August 2, 2012</td>
<td>August 2, 2014</td>
<td>November 28, 2013</td>
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<td>Appendix D - Illness/Injury Sensitivity Index-Revised</td>
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<td>Appendix E - Distress Tolerance Scale</td>
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<td>Appendix F – Contact Information Page</td>
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<td>Appendix G – Recruitment Poster</td>
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<td>Appendix H – Consent Form</td>
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<td>Appendix I – Phone Interview Guide</td>
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**AMENDMENT CERTIFICATION**

The University of Regina Research Ethics Board has reviewed the changes to the above-named research project as outlined in your memo dated November 20, 2013 and they are approved.

**ONGOING REVIEW REQUIREMENTS**

In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: [http://www.uregina.ca/research/REB/main.shtml](http://www.uregina.ca/research/REB/main.shtml)

Dr. Larena Hoeber, Chair
University of Regina
Research Ethics Board

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University of Regina
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