INVESTIGATING THE ANXIOLYTIC EFFECTS OF AEROBIC EXERCISE FOR THE TREATMENT OF POSTTRAUMATIC STRESS DISORDER

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Abstract

Preliminary evidence has demonstrated the anxiolytic capabilities of aerobic exercise; however, the treatment potential for posttraumatic stress disorder (PTSD) has received comparably less attention. Aerobic exercise may work similar to interoceptive exposure therapy–an empirically supported treatment for PTSD–but this hypothesis has received scarce empirical attention. The current study investigated the therapeutic potential (i.e., whether or not PTSD symptoms, anxiety sensitivity [AS], and depressive symptoms would decline) and mechanisms (i.e., whether or not therapeutic benefit is changed by increasing or decreasing interoceptive awareness) of a brief aerobic exercise program for individuals with PTSD. Thirty-three participants (M_{age}=36.9 years; 76% female; 18% drop-out rate) with PTSD were recruited from the surrounding community and completed two weeks of aerobic exercise (six sessions) on a stationary bike. Participants were randomized into three groups to direct their cognitive focus during exercise, thereby testing hypothesized therapeutic agents; group one (cognitive distraction) watched a nature documentary, group two (exercise only) exercised in silence with no distractions, and group three (interoceptive exposure) received interoceptive prompts. Data was collected at pre-treatment, after each exercise session, and one week and one month after treatment ended. Hierarchal linear modeling indicated that each variable decreased significantly in a quadratic fashion; specifically, scores tended to reduce steadily from baseline to their lowest point after the last exercise session and steadily rose during the follow-up period. The effect of group membership was largely not statistically significant, whereas the interaction between time and group membership was significant among hyperarousal symptoms, fear of physical sensations, and fear of socially

observable symptoms. In cases where interactions were present, between group comparisons suggested that the interoceptive prompts group consistently reported less change on primary outcome variables than the remaining groups. Given that the decline in outcome variables was present in each of the three study groups, results suggest that aerobic exercise is effective regardless of cognitive focus during exercise. Notwithstanding, given the subjacent impact of the intervention among interoceptive exposure group participants, anxiolytic properties of aerobic exercise may be accented in the short term by employing strategies to detract from the discomfort of the exercise protocol.

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1. Literature Review

Anxiety disorders are the most prevalent of all psychological disorders, exerting tremendous economic strain on those affected and on the Canadian healthcare system (Gum, King–Kallimanis, & Kohn, 2009; Greenberg et al., 1999). One of the most severe anxiety disorders (recently re–conceptualized as a trauma–and stress–related disorder in the most recent version of the Diagnostic and Statistical Manual of Mental Disorders – 5th edition [DSM–5], American Psychiatric Association [APA], 2013) is posttraumatic stress disorder (PTSD; Taylor, 2006). Individuals with PTSD suffer a constellation of distressing symptoms, including emotional numbness, distressing physiological arousal, depression, and re–experiencing of the traumatic event through flashbacks and nightmares (APA, 2013). In addition, those with PTSD utilize medical healthcare services far more frequently than individuals with other mental disorders, often leading to unnecessary economic strain on our healthcare system (Cohen et al., 2009). Indeed, a recent body of evidence supports a direct link between PTSD and reduced physical health quality (Asmundson, Stein, & McReary, 2002), including higher instances of medical conditions such as musculoskeletal (Asmundson, Abrams, & Collimore, 2008; Fetzner, McMillan, & Asmundson, 2012) and circulatory (Sareen, Cox, Clara, & Asmundson, 2005) disorders. Combined with the damaging social and interpersonal expense (Taylor, 2006), the aggregated cost of PTSD is substantial.

Recent research concerning vulnerability and maintenance factors has underscored the robust contribution of fear of arousal–or anxiety sensitivity (AS; i.e., the propensity to fear anxiety–related sensations based on the belief that they have negative consequences; Reiss & McNally, 1985)–to PTSD symptoms (Asmundson & Stapleton,

2008; Collimore, McCabe, Carleton, & Asmundson, 2008; Fetzner, Collimore, Carleton, & Asmundson, 2011; Keogh, Ayers, & Francis, 2002). AS comprises three dimensions, including fears of bodily sensations, cognitive dyscontrol, and socially observable symptoms (Taylor, et al., 2007). Researchers have found that the AS fears of bodily sensations dimension (e.g., racing heart, shortness of breath) is most closely linked with escalation of PTSD symptom severity when compared to other AS dimensions (Collimore et al., 2008; Fetzner et al., 2011). Important in this regard, emerging evidence suggests that interoceptive exposure techniques aimed at reducing fear of bodily sensations are beneficial in the treatment of PTSD (e.g., Wald & Taylor, 2008).

Given evidence of successes in reducing PTSD severity by targeting and facilitating habituation of fear of bodily sensations, another promising treatment modality for PTSD may be aerobic exercise. To this end, aerobic exercise has been posited to function as a type of interoceptive exposure–a technique which has shown potential in treating PTSD through graduated exposure to feared bodily sensations (Wald & Taylor, 2008). In recent decades, research has found that aerobic exercise regimens reduce depressive symptoms among those with major depressive disorder (Goodwin, 2003), and fear of bodily sensations among both depressed and anxious individuals (Smits et al., 2008). Furthermore, aerobic exercise has been found to influence neurochemical changes similar to that of antidepressant medication (Chaouloff, 1997)–a common first line intervention for PTSD (Taylor, 2006). The benefits of aerobic exercise also include reduced intensity of rumination and worries (Bahrke & Morgan, 1978; Leith, 1994), interrupting social withdrawal (Hopko, Lejuez, Ruggiero, & Eifert, 2003; Jacobson et al., 1996), development of a sense of mastery (Craft, 2005), and improved physical fitness

(for review see Stathopoulou, Power, Berry, Smits, & Otto, 2006). Additionally, reduced prevalence of physical health conditions known to be highly comorbid with PTSD (e.g., musculoskeletal disorders; Morken, Magerøy, & Moen, 2007) have been noted as a benefit of aerobic exercise**.** The United States National Institute of Mental Health has recognized the link between physical activity and emotional well–being, and has long emphasized the need for methodologically sound investigations into the working mechanisms that underlie the mental health benefits precipitated by exercise (Morgan & Goldston, 1987). However, the impact of aerobic exercise on PTSD and the mechanisms of exercise responsible for reductions in AS remain unexplored (Stathopoulou et al., 2006). The purpose of the current study was to examine the anxiolytic effects of aerobic exercise for individuals with PTSD, as well as investigate the working mechanisms responsible for the potential therapeutic effects.

The following sections provide a review of pertinent contemporary PTSD literature, including current diagnostic criteria, prevalence, and explanatory models. Details on the application of physical exercise to ameliorate anxiety, anxiety and trauma–related disorder symptoms, and associated risk factors will also be provided. Particular focus will be directed towards potential mechanisms posited to be responsible for the therapeutic effect of aerobic exercise, including: improvements in physical fitness, neuroendocrine and thermoregulatory adaptations, distraction from anxiety, reduction in AS, and exposure to feared bodily sensations.

1.1 Posttraumatic Stress Disorder.

Given the timing of the current study, the majority of the discussion surrounding the diagnostic criteria for PTSD will focus on criteria outlined in the Diagnostic and

Statistical Manual of Mental Disorders (DSM), fourth version text revision (IV–TR; APA, 2000). In addition, information on changes to these criteria in DSM–5 (APA, 2013) will be briefly discussed. In DSM–IV–TR, PTSD is an anxiety disorder that may develop after exposure to an extremely stressful or frightening event whereby actual or threatened death, serious injury, or threat to one's physical integrity may occur (APA, 2000). The first formal conceptualization of PTSD was in the first version of the DSM (APA, 1952) as "traumatic war neuroses" in large part because of the aftermath of major war conflicts (e.g., World War II) and humanitarian catastrophes (e.g., the Holocaust; Keane, Taylor, & Penk, 1997). Political and public conceptualizations of major traumatic events (e.g., the Vietnam War) continued to impact the diagnostic structure of the disorder up to and beyond the second revision of the DSM (APA, 1968) which re–formulated and labelled the disorder as "transient situational stress reactions" (APA, 1968). It was not until 1980 with the advent of the third DSM revision (APA, 1980) that PTSD received its current diagnostic label.

1.1.1 DMS–IV–TR diagnostic criteria. The necessary feature of PTSD is exposure to a traumatic event which includes real or threatened death or threats to one's own or others' physical integrity (Criterion A1), and a reaction involving intense fear, helplessness, or horror (Criterion A2; APA, 2000). Subsequent PTSD symptoms comprise three clusters including persistently re–experiencing the event (re–experiencing; Criterion B); avoidance of stimuli associated with the trauma and a general responsiveness not present prior to the trauma (avoidance/numbing; Criterion C); and symptoms of increased arousal (hyperarousal; Criterion D). These symptoms must persist

for at least one month past the date of the trauma exposure (Criterion E) and cause clinically significant distress or impairment (Criterion F).

According to Criterion B, re–experiencing symptoms entail recurrent and intrusive distressing recollections of the event (APA, 2000) despite attempts to stop their reoccurrence (Taylor, 2006). Re–experiencing symptoms may also occur during sleep as thematically related nightmares. Additionally, individuals may report intense psychological and physiological reactions at exposure to trauma related cues. Endorsement of Criterion B requires the presence of at least one characteristic symptom including, recurrent and intrusive distress recollections of the event, recurrent distressing dreams of the event, acting or feeling as if the traumatic event were recurring, intense psychological distress at exposure to trauma related cues, and physiological reactivity on exposure to trauma–related cues.

Criterion C symptoms comprise effortful avoidance of trauma related cues and restricted range of affect. Known commonly as avoidance/numbing symptoms, endorsement entails at least three characteristic symptoms including efforts to avoid thoughts, feelings, conversations, activities, places or people that are related to or cause recollections of the trauma; inability to recall important aspects of the trauma; diminished interest or participation in previously enjoyed activities; a restricted range of affect; or sense of foreshortened future (APA, 2000). Avoidance/numbing symptoms have been posited as an attempt by affected individuals to gain distance from the trauma and subsequent re–experiencing symptoms (Creamer, Burgess, & Pattison, 1992). The avoidance/numbing symptom cluster is grouped together in the current DSM–IV–TR (APA, 2000); however, recent evidence suggests that it represents two distinct symptom

clusters (Asmundson, Stapleton, & Taylor, 2004; King, Leskin, King, & Weathers, 1998; Shelby, Golden–Kreutz, & Anderson, 2005). Therefore, avoidance and numbing will be examined separately in the current study.

Criterion D includes symptoms of increased arousal. Referred to commonly as hyperarousal symptoms, such symptoms reflect a constant state of fight or flight similar to the individual's bodily reaction during the precipitating traumatic event (Resick, Monson, & Rizvi, 2008). Endorsement of Criterion D requires at least two characteristic symptoms including difficulties falling or staying asleep; irritability or outbursts of anger, concentration difficulties; or feeling jumpy or on edge (APA, 2000).

1.1.2 DSM–5 changes to diagnostic criteria. DMS–5 criteria for PTSD include a number of notable changes from DSM–IV–TR. First, PTSD no longer falls under the anxiety disorder category; instead, it now exists in a newly developed "trauma– and stressor–related disorders" category along–side acute stress disorder, disinhibited social engagement disorder, adjustment disorder, and reactive attachment disorder (APA, 2013). Second, the definition of trauma has changed to include a more explicit description of the event (formerly Criterion A1 in DSM–IV–TR) and omit the subjective appraisal of the severity of the event (formerly Criterion A2 in DSM–IV–TR). Third, whereas DSM–IV–TR had combined the avoidance and numbing symptoms into a single symptom cluster, DSM–5 has separated them into 1) avoidance and 2) persistent negative alterations in cognitions and mood. Fourth, three new symptoms have been added, including: persistent and distorted blame of self or others (Criteria D, persistent negative alterations in cognitions and mood); persistent negative emotional states (Criteria D, persistent negative alterations in cognitions and mood); and reckless or destructive behavior

(Criteria E, hyperarousal). Fifth, a clinical subtype "with dissociative symptoms" was added. Lastly, separate criteria have been added for children age 6 years or younger; however, given that the focus of this study is on adults, such criteria will not be reviewed.

1.1.3 Etiological models. Numerous etiological models have been proposed to explain the development and maintenance of PTSD. The following sections will focus on three specific cognitive–behavioral models including the (1) conditioning model (Mowrer, 1960; Rescorla, 1988), (2) emotional processing model (Foa & Kozak, 1986; Foa, Steketee, Rothbaum, 1989; Foa & Rothbaum, 1998), and (3) cognitive model of PTSD (Ehlers & Clark, 2000). Although other models have received empirical attention and validation (e.g., dual representation model; for a review see Taylor, 2006), the following section will focus on those models that have been the most effective in explaining the core diagnostic symptoms of PTSD.

1.1.3.1 The conditioning model of PTSD. The conditioning model suggests that PTSD is manifested by fears acquired by classical conditioning. Take for example a soldier who has gone on to develop PTSD as a result of surviving an insurgent attack. According to the conditioning model of PTSD, during the causal event, an unconditioned stimulus (insurgent attack) evokes an unconditioned response (fear of pain/death). An association is then learned between the unconditioned stimuli and innocuous stimuli (hot day, nearby market). Other associations are learned which are paired with the conditioned response (fear). As such, the soldier may experience intense fear when in crowded places similar to the market where the original traumatic event. Furthermore, the soldier may learn that his fears can be minimized by safety behaviours such as hyper vigilance and

avoidance of trauma–related stimuli; consequently, he may intentionally avoid crowded areas and be irritable and on edge when around even small groups of people.

1.1.3.2 The emotional processing model of PTSD. The emotional processing model of PTSD holds that PTSD arises from a fear structure contained in the long–term memory that contains representations of feared stimuli, response formation, and meaning information. These three types of information are thought to be linked, affecting one another in the event of trauma. In keeping with the previous example, the soldier's long–term memory contains information about feared stimuli (pain and death), response formation (palpitations, trembling, fear for safety), and the meaning information (the concept of danger). In response to the trauma, links are created between stimuli (hot days; crowded areas) and meaning of danger (being in a crowded area on a hot day means danger). These links are learned, albeit in most cases erroneously, through classical conditioning processes. The soldier will be more likely to believe the world is a dangerous place, and endorse erroneous generalizations about himself and his role in the attack. Furthermore, the soldier will have a lower activation threshold for his fear structures because of a wide range of triggering stimuli. His fear structures will then activate when current information is interpreted as matching that which is stored in the memory network.

1.1.3.3 The cognitive model of PTSD. The cognitive model of PTSD holds that PTSD becomes persistent when the individual is confronted by a traumatic event, and processes the event in a way that leads to a sense of serious and current threat. Current threat is said to arise from a number of potential processes arising post trauma. First, affected individuals tend to engage in data–driven processing rather than conceptualizing

the meaning and implications of the event. In keeping with the previous example, the soldier may interpret the insurgent attack in a purely sensory context and refrain from conceptualizing the event into his worldview. As a result, the soldier may have a reduced ability to elaborate and contextualize the meaning of the trauma, and have a strong associative memory linking noxious stimuli with fear responses. Ultimately, the paucity of conceptualization of the traumatic event will disable the soldier from engaging in posttraumatic growth and coping adaptively in the aftermath of trauma.

Individuals with PTSD also have a tendency towards excessive negative appraisals regarding the cost of further aversive events (e.g., the soldier may question his ability to react effectively to similar situations, or appraise similar environments as inevitably leading to danger and injury). In addition, they tend to underestimate their competency to deal with subsequent trauma. Appraisals are generalized to include negative interpretations of the trauma, its consequences, and the world. As a result of these negative appraisals and underestimation of personal competency, maladaptive coping strategies are employed in order to avoid trauma cues. In the end, maladaptive coping strategies serve to perpetuate PTSD symptoms because they do not allow for corrections of erroneous appraisals.

1.1.4 Prevalence. Studies in recent decades have suggested that the prevalence of PTSD in the general population ranges anywhere from 1% to 11% (for review see Afifi, Asmundson, & Sareen, 2009). In the United States, 7.8% of the general population has been found to show symptoms consistent with DSM–IV PTSD diagnosis over the course of their lifetime (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995), whereas 9.2% of Canadians have been found to display similar symptoms (Van Ameringan, Mancini,

Patterson, & Boyle, 2008). Although not unanimous across all studies (e.g., Creamer, Burgess, & Mcfarlane, 2001), a plethora of studies have found that women are up to twice as likely as males to develop PTSD after a traumatic event (for review see Afifi et al., 2009). Risk factors that may explain the between–sex differences include pre–existing anxiety or mood disorders and greater exposure to traumatic events (Breslau, Davis, Andreski, Peterson, & Schultz, 1997). Increased exposure to specific traumatic events which have been found to garner greater instances of PTSD may also contribute to increased prevalence of PTSD among women. For example, women are more likely to be confronted with sexual assault, whereas men are more prone to experience physical assault (Norris, 1992; Kessler et al., 1995). Such differences in trauma type have been shown to affect the frequency of PTSD development as well as severity of symptoms (Collimore, Asmundson, Taylor, & Jang, 2009).

1.1.5 Prevalence among at–risk populations. Considerable research has focused on elucidating the course and likelihood of developing psychopathology following individual traumatic experiences. In particular, sexual trauma (Creamer et al., 2001; Noris et al., 1992), military combat (e.g., Prigerson, Macijewski, & Rosenheck, 2001), and adverse childhood events (Bromet, Sonnega, & Kessler, 1998; Yehuda, Halligan, & Grossman, 2001) have consistently generated elevated rates of PTSD in research studies when compared to other traumatic events. Consequently, those at risk for exposure to such trauma demonstrate increased likelihood for development of PTSD. In fact, exposure to sexual trauma among females and military combat among males has arguably demonstrated the strongest associations with PTSD onset throughout contemporary literature (for review see Afifi et al., 2009). Traumatic events precipitating the

development of PTSD have also been noted as a diathesis for other deleterious mental health outcomes (Goldberg, Eisen, True, & Henderson, 1990) such as alcohol–use disorders (Fetzner et al., 2011) and suicide (Flannery, Singer, & Wester, 2001).

Sexual assault victims have been identified as being at an increased risk for PTSD development. Indeed, the preponderance of research suggests sexual abuse in both childhood (e.g., Kendall–Tackett, Williams, & Finkelhor, 1993) and adulthood (e.g., Maker, Kemmelmeir & Peterson, 2001) have implications for PTSD as well as a host of psychopathologies (e.g., substance dependence disorders; Thompson et al., 2003). A history of childhood sexual abuse has also been found to predict increased vulnerability for adult sexual and physical victimization and increased PTSD symptoms severity resulting from the cumulative effect of subsequent adult traumas (Nishith, Mechanic, & Resick).

Due to the nature of military service wherein members are subject to increased instances of trauma compared to civilians, military groups have long been recognized as an at–risk group for development of PTSD. The prevalence of PTSD among military service–members varies depending on the data source and population studied. For example, up to 30.9% of veterans who participated in the Vietnam War met diagnostic criteria for PTSD at some point after deployment, and 15.2% had persistent PTSD symptoms approximately two decades later (Kulka et al., 1990). Notwithstanding, more recent criticisms regarding the reported rates among Vietnam veterans have prompted further investigation into the prevalence of PTSD (e.g., Dohrenwend et al., 2006). The subsequent studies provided evidence supporting rates of pathology of approximating 18.7%, which while lower than initially thought, remain quite high (Dohrenwend et al.,

2006). Similar findings have been reported for military and para–military populations participating in such conflicts as operations Enduring and Iraqi Freedom, wherein 16.6 to 21.5% of American military service–members met criteria for current PTSD (Hoge, Terhakopian, Castro, Messer, & Engel, 2007; Pietrzak et al., 2009). Similar prevalence rates of PTSD among Canadian military personnel have been found (14.8%; Richardson, Naifeh, & Elhai, 2007). Military deployment related events such as exposure to combat and witnessing atrocities or massacres were found to be most associated with increased rates of PTSD among a representative sample of deployed military personnel (Sareen et al., 2007). Likewise, research has also found a linear relationship between the increased exposure to intense firefights and probability of PTSD among American soldiers deployed to Iraq and Afghanistan (Hoge et al., 2004).

1.1.6 Adherence and drop–out in traditional evidence–based treatments for PTSD. Treatment seeking behaviours, adherence, and success of intervention are salient issues in the treatment of individuals with PTSD. Indeed, population based studies have found that upwards of 21.9% of individuals screening positive for PTSD feel no need for health care treatment, including therapy or counselling (Sareen et al., 2007). Furthermore, PTSD has been found to associate with increases in missed treatment appointments, lower levels of treatment adherence, and decreases in positive clinical outcomes (Brown et al., 2001; Sullivan et al., 2003). Moreover, chronic PTSD and increased symptom severity have been found to be associated with reduced instances of treatment seeking behaviour, subjective appraisals of reduced control over symptoms, and increases in self–medicating behaviour (Spoont, Sayer, & Nelson, 2005). Compounded with common barriers to care reported by individuals with PTSD including lack of confidence in the

health care system to provide assistance, interference with work–life, and lack of availability of health services (Sareen et al., 2007), traditional therapeutic interventions for PTSD face many challenges.

Beyond help–seeking behaviours, individuals with PTSD have been found to hold strong negative health beliefs which likewise act to reduce the likelihood that one will seek and successfully complete treatment (Spoont et al., 2005). Furthermore, the subjective belief about the traumatic event itself has been found to adversely affect one's ability to adequately self–appraise the severity of one's symptoms which culminates with reduced likelihood of successful treatment outcome (Frazier et al., 2001; Koss et al., 2002; Regehr et al., 1999). Given the aforementioned problems with traditional front–line psychotherapeutic treatments for PTSD, in concert with the barriers commonly brought on by traumatization and PTSD itself, studies into potential adjuncts to therapeutic interventions may serve to increase treatment adherence and outcomes for affected individuals.

1. 2 Physiological Consequences of PTSD.

A wealth of evidence suggests that PTSD mediates the relationship between trauma and physical health (e.g., Green & Kimerling, 2004). Consequently, the physiological consequences engendered by PTSD may further embolden the therapeutic potential for aerobic exercise as a treatment for PTSD. In particular, PTSD has been found to increase risk for cardiovascular disorders (e.g., Sareen et al., 2007) and precipitate deleterious neurochemical changes (e.g., Yehunda, 2004). Elements of aerobic exercise may work to either reverse of circumvent such consequences when applied in appropriate duration and dosage.

Friedman and Shnurr (1995) hypothesized that biological processes associated with PTSD may work to contribute to adverse cardiovascular consequences. In particular, cardiovascular reactivity as a result of autonomic system hyperarousal can lead to elevations in resting heart rate and heightened diastolic blood pressure (Buckley & Kaloupek, 2001). People with PTSD have also been found to have overly heightened attenuation and responses to neutral stimuli (e.g., sudden loud noises) when compared to non–PTSD affected persons (Yehunda, 2002). Decreased cardiovascular ability may, therefore, be at least partially explained by chronically elevated levels of stress effecting autonomic system functioning. Aerobic exercise may act to counteract such processes by providing an opportunity for the body to increase tolerance of such processes.

The neurochemical changes which accompany PTSD include a number of variations; briefly, findings in contemporary research implicate cortisol and the hypothalamic-petuitary-adrenal axis (Yehuda, 2004; Young & Breslau, 2004), noradrenergic dysregulation (Geracoti et al., 2001), and serotonergic dysregulation (e.g., Southwick et al., 1997) as adversely affecting individuals with PTSD. Each of the three aforementioned processes has been found to relate to common PTSD symptoms. Normal stress responses involve an increase in the secretion of cortisol; yet, many individuals affected by PTSD have been found to have persistently high levels of cortisol. As such, PTSD may involve a failure to shut down the cortisol response. Noradrenergic dysregulation has been found to relate to fear and arousal responses in the face of trauma–related cues (McFarlane et al., 2002). Finally, serotonin, noted to modulate a variety of brain structures and neurotransmitter systems, has been found to lead to symptoms such as hyperarousal and re–experiencing symptoms (Southwick et al., 1997).

Therefore, processes which regulate such neurochemical systems can work to reduce PTSD symptoms in affected individuals.

The positive effects of acute aerobic exercise may act to counter the deleterious physiological consequences and thereby provide therapeutic relief for affected individuals. Neurochemical changes similar to antidepressant medication have been recognized among individuals participating in aerobic exercise regimens within several weeks of activity (e.g., Blumenthal et al., 2007). Acute aerobic exercise has also been found to increase endorphin production which may counteract negative mental health consequences of PTSD (Hoffman, 1997). Moreover, chronic exercise has been found to increase one's propensity to cope with changes in physiological homeostasis (e.g., increases in body temperature) similar to that of anxiety (e.g., Koltyn & Morgan, 1997).

1.3 Physical Exercise: Prevalence, Explanations, and Mental Health Correlates.

International and Canadian guidelines recommend that adults should accumulate at least 150 minutes of moderate to vigorous physical activity every week in order to obtain substantial health benefits (Public Health Agency of Canada, 2011); nonetheless, only 15% of Canadians (17% men; 14% women) reported obtaining this amount (Statistics Canada, 2011). In contrast, Canadian adults spend an average of 9.5 hours a day (69% of waking hours) in sedentary activities (e.g., watching television; Statistics Canada, 2011). Exercise literature has conceptualized this lack of exercise within the general population in a number of ways including deficient self–motivation or self–efficacy, inappropriate health beliefs, or lack of an internal locus of control (for review see Salmon, 2001). Much attention has focused on the deleterious physical consequences

to lack of exercise in adults; however, the positive mental health benefits resulting from physical activity have garnered increasing amounts of attention as well.

Evidence of the positive mental health benefits of physical exercise have been interpreted in large scale population–based studies. In a study examining over 55,000 residents of Canada and the United States, individuals reporting regular exercise had fewer instances of depression than those reporting no regular exercise engagement (Stephens, 1988). Similarly, in a study of over 19,000 individuals from the Netherlands it was found that regular exercise was associated with lower levels of anxiety and depression (De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006; Goodwin, 2003). Population–based studies have also found physical exercise to predict psychological wellbeing (Hassmén, Koivula, & Uutela, 2000), lower levels of neuroticism (De Moor et al., 2006) and psychiatric disorders (Goodwin, 2003), as well as higher levels of extraversion and sensation seeking (De Moor et al., 2006). Indeed, positive sequelae resulting from physical exercise are consistently found across a number of countries and populations.

Research focusing on the positive mental health benefits associated with physical activity has expanded in recent decades. Indeed, the US National Institute of Mental Health has recognized the link between physical activity and emotional well–being, and has long emphasized the need for methodologically sound investigations into the working mechanisms that underlie the mental health benefits precipitated by exercise (Morgan & Goldston, 1987). Typically, exercise regimens investigated in contemporary literature include both aerobic–physical activity requiring the use of oxygen in the body's metabolic process–or anaerobic exercise–physical activity intense enough to trigger non–

oxygen consumption metabolic processes. Alternative forms of exercise such as stretching (Dunn, Trivedi, Kampert, Clork, & Chambliss, 2005), martial arts (Hoffmann–Smith, Ma, Cheng–Tsung, DeGuire, & Smith, 2009), and meditation (e.g., yoga; Evans et al., 2008) have also been investigated. To summarize this extensive body of literature, research has largely been interpreted to suggest a wide variety of physical activities can engender positive psychological benefits; to follow is a more specific overview of the anxiolytic effects of physical activity recognized in contemporary literature.

1.4 Anxiety Disorders and Physical Exercise

The mental health benefits of physical exercise as they pertain to mental disorders in clinical populations have only recently been investigated. Particular attention has been given to the therapeutic effects on mood disorders (e.g., Smits et al., 2008), whereas research examining the relationship between physical exercise and anxiety disorders is less established (for review see Asmundson et al., 2013). Notwithstanding, exercise has demonstrated reliable therapeutic effects in research examining panic disorder with and without agoraphobia (e.g., Esquivel et al., 2008; Smits, Meuret, et al., 2008; Pfaltz et al., 2010), obsessive–compulsive disorder (e.g., Abrantes et al., 2009), specific phobia (e.g., Goodwin, 2003), and generalized anxiety disorder (e.g., Koszycki et al., 2007; Evans et al., 2008; Merom et al., 2007). Furthermore, the preponderance of research examining prevalence of anxiety disorders have found reduced instances in physically active individuals (Meyer & Broocks, 2000).

A number of different types of exercise have proven effective in ameliorating distressful symptoms of mental disorders including low (e.g., Bibeau, Moore, Mitchell, Vargas–Tonsing, & Bartholomew, 2010) and high intensity (Broman–Fulks, Berman,

Rabian, & Webster, 2004) aerobic, anaerobic (e.g., Chmelo, Hall, Miller, & Sanders, 2009), tai–chi (Hoffmann–Smith et al., 2009), and yoga (Koszycki et al., 2007). Furthermore, research has consistently found gains made as a result of physical activity can be realized across age groups (e.g., Diaz & Motta, 2008; Penninx et al., 2002). Although both anaerobic and aerobic exercise have been shown to have anxiolytic effects for individuals with anxiety disorders, given that the current study will utilize an aerobic exercise paradigm, the remainder of the review will focus on aerobic exercise.

1.4.1 PTSD and aerobic exercise. To date, only three studies have examined the anxiolytic effects of aerobic exercise for the treatment of PTSD symptoms. The first study was conducted by Manger and Motta (2005), wherein they applied a 12 week aerobic exercise program to a small sample (n =9) of PTSD affected adults who had been exposed to a heterogeneous trauma history. Participants were asked to warm up for 10 minutes and then conduct 30 minutes of walking or jogging while staying between 60% and 80% of their maximum heart rate. Results were promising, indicating that PTSD symptoms reduced between baseline and post–treatment (p = .008) and follow–up (p = .011).

A second study conducted by Newman and Motta (2007) extended the aforementioned work by examining if such effects could be found among adolescent females. Fifteen participants between the ages of 14 and 17 who had PTSD engaged in aerobic exercise for eight weeks, three times weekly, for at least 20 minutes. The researchers allowed for participants to choose which aerobic exercise they wanted to engage in. Results demonstrated that the intervention had a large effect on the reduction of PTSD symptoms (d = 1.89) and posttraumatic stress reactivity (d = 6.20). Gains were

maintained through one month follow–up; as well, the majority of participants reported clinically significant gains.

Finally, Diaz and Motta (2008) conducted a study similar to that of Newman and Motta (2007) using 12 female adolescents with PTSD. Participants were mostly Latina and African American and were asked to engage in outdoor speed–walking, working between 60% and 90% maximum heart rate. The aerobic exercise program lasted for five weeks for a total of 15 sessions, wherein participants were required to walk a distance of 1.5 miles in 23 minutes. Results demonstrated that more than 90% of participants had reductions in PTSD severity which were maintained at a one month follow–up.

The three aforementioned studies provide preliminary optimism for the application of aerobic exercise as a treatment for PTSD; notwithstanding, a number of methodological issues and key areas of extension provide direction for future research. First, each of the studies relied on relatively small sample sizes and participants were recruited through convenience sampling (i.e., all members of psychiatric center service utilizers; Diaz & Motta, 2008; Newman & Motta, 2007). The samples utilized in these studies were also relatively heterogeneous in age, sex, and ethnicity. Second, the aerobic exercise prescribed in each of the studies was either not, or loosely, standardized. More specifically, exercise was not supervised by trained and qualified individuals, or participants were left to exercise entirely on their own initiative. The consequence of this non–standardization is that the effects recognized cannot be attributed to a specific dosage of exercise. Third, previous studies were concerned with whether or not aerobic exercise would reduce PTSD symptoms rather than investigating working mechanisms involved in the therapeutic effect. Such investigations may serve to assist clinicians to

understand the most effective delivery method of such interventions should they be found effective for symptom amelioration.

1.5 Potential Mechanisms Responsible for the Anxiolytic Effects of Aerobic Exercise.

Although empirical evidence has largely supported the anxiolytic effects of aerobic exercise, the majority of research has focused on the anxiolytic effects of formal exercise programs rather than identifying the potential mechanisms responsible. Although not fully understood, researchers agree that the therapeutic effects of any physical exercise are most likely a complex intermingling of psychological and physiological factors. Contemporary literature provides a theoretical basis for speculation of mechanisms that appear to be activated by physical activity. In the next section, preliminary findings and theoretical speculation pertaining to the foremost suppositions appearing in contemporary literature will be discussed. Although there are a number of different theories regarding the anxiolytic effects of aerobic exercise, several are more central to the current study (e.g., reductions in AS and exposure to feared bodily sensations) and as such will be focused on in greater detail. Other theories less relevant to the current study (i.e., improved fitness, neurochemical thermoregulatory changes, distraction) will be summarized in less detail. Given that very few studies have examined the therapeutic effects of aerobic exercise on individuals with PTSD, the following sections will focus on mechanisms responsible for reductions in anxiety non–specific to PTSD.

1.5.1 Improved physical fitness. Individuals with psychiatric conditions have been found to have lower levels of physical fitness–which in psychological research has

largely been defined by aerobic capabilities (Salmon, 2001)–compared to healthy controls (Meyer & Broocks, 2000); therefore, physical exercise interventions may be particularly effective for such individuals. Although changes in aerobic fitness levels have not been specifically linked with reductions in anxiety (Herring, O'Connor, & Dishman, 2010), aerobically trained individuals (i.e., active in heavy aerobic activities with an average estimated maximal oxygen uptake = 32.8 ml/kg.min [$\pm$1.2]) have been found to have more rapid recovery from both physiological and subjective dimensions of emotionality and stress (Sinyor et al., 1983). Physical fitness has also been found to limit increases in heart rate which occur during physiological and psychological stress (Sinyor, Schwartz, Peronnet, Brisson, & Seraganian, 1983), facilitate faster returns to baseline heart rate from aroused states (Strohle, 2009), reduce norepinephrine and cortisol production during arousal (Peronnet et al., 1981; White, Ismail, & Bottoms, 1979), and decrease accumulation and increase elimination of lactic acid from the bloodstream (Winder, Hickson, Hagberg, Ehsani, & McLane, 1979), all of which promote the body's efficiency to physiological stress and reduce predictors of anxiety disorders (Strohle, 2009). Further, after participating in brief aerobic exercise programs (e.g., 8 weeks of mild intensity jogging groups; Nabkasorm et al., 2005) mentally disordered persons have been found to have greater maximal oxygen consumption (Nabkasorn et al., 2005), increased lung capacity and reduced CO_2 sensitivity, which have been shown to predict anxious reactions among those with anxiety disorders (Blechart, Wilhelm, Meuret, Wilhelm, & Roth, 2010).

Notwithstanding, although numerous benefits accompany improvements in aerobic fitness, these benefits are not necessarily responsible for the anxiolytic effects of

physical exercise. Indeed, psychological benefits have been recognized when applying short aerobic exercise regimens (e.g., 6 sessions over 2 weeks, Smits et al., 2008) effectively reducing the potential impact of aerobic fitness improvements which typically require at least 10 to 12 weeks of training in order to ascertain demonstrable cardiovascular conditioning (Salmon, 2001). Given that psychological changes are often recognized when applying acute bouts of exercise (for review see Asmundson et al., 2013), and physical changes generally require more persistent and chronic exercise (Salmon, 2001), changes in aerobic fitness and prolonged activity regimens may not be necessary for therapeutic gains to be made when engaging in aerobic exercise.

1.5.2 Neuroendocrine and thermoregulatory adaptations. At the neuronal level, both strenuous (e.g., running) and more passive (e.g., walking) physical exercise has been found to enhance neurochemical activity promoting resilience to stressful mood states (O'Connor, Raglin, & Martinsen, 2000; O'Connor, Smith, & Morgan, 2000). Specifically, neuroendocrine adaptations (Dishman, 1997), increases in body temperature (Koltyn & Morgan, 1997), changes in central serotonergic systems (Chaouloff, 1997), and increases in endorphin production (Hoffman, 1997) following exercise have been posited as mechanisms by which physical exercise regulate negative psychological states. Although the specific neurochemical biology and anatomy at work during physical exercise is beyond the scope of this review, general outlines of neuroendocrine effects may aid in the description of the potential therapeutic mechanisms at work.

Thermoregulatory mechanisms are known to influence homeostasis which becomes threatened during physiological arousal (for reviews see Klimes–Dougan, Hastings, Granger, Usher, & Zahn–Waxler, 2001; Leong–Lim, Byrne, & Lee, 2008).

Increases in metabolic heat production during physical exercise therefore, similarly poses a threat to anxiolytic responses and thermoregulation by causing substantial increases in metabolic heat production. In concert, physical exercise generates exposure to sub–lethal homeostatic changes which mimic similar anxious neurochemical processes; in turn, physical exercise may facilitate tolerance to higher doses of stress (Leong–Lim et al., 2008). Similarly, production of beta–endorphins, adrenocorticotropic hormone, and endogenous opioid peptide neurotransmitters serving analgesic purposes serve to induce anxiolytic effects at the neuronal level. Indeed, physical exercise has been posited to stimulate a concomitant release of the aforementioned hormones, which counteract the neurological consequences of stress (Steinberg & Sykes, 1985). Research examining peripheral blood levels has found elevations in beta–endorphins and adrenocorticotropic hormones after various types of exercise and subsequent reductions in anxiety (de Meirleir et al., 1986).

1.5.3 Distraction. The role of distraction as a mechanism responsible for anxiolytic effects of physical exercise has been conceptualized as both facilitating and detracting from the therapeutic potential of physical exercise. In particular, engagement in physical exercise has been proposed as providing an escape from daily stresses and concerns; for this reason, another posited mechanism at work during physical exercise may be distraction from anxious thoughts (Broocks et al., 1998; Paluska et al., 2000; Salmon, 2001). Indeed, physical activity may provide an opportunity to become engaged in an activity that detracts attention away from negative and catastrophic thoughts which are common among those with anxiety disorders (Salmon, 2001).

In contrast, distraction during physical exercise may hinder other anxiolytic mechanisms during physical activity. Specifically, physical exercise may reduce anxiety by facilitating exposure of bodily sensations similar to that experienced during anxiety (Beck, Shipherd, & Zebb, 1997). As such, distraction from bodily sensation may induce the opposite of intended therapeutic effect and reinforce avoidance behaviours. For this reason, researchers often remind participants to focus on their bodily sensations during aerobic exercise to ensure that they receive sufficient exposure to physiological sensations similar to anxiety responses (Smits et al., 2008).

1.5.4 Reductions in AS and exposure to feared bodily sensations (interoceptive exposure).

AS, or the propensity to fear anxiety sensations based on the appraisal that they will lead to catastrophic consequences (Reiss & McNally, 1985), has received much empirical attention as an important variable in the study of anxiety disorders. AS has been identified as comprising three dimensions including fear of bodily sensations, socially observable symptoms, and cognitive dyscontrol (Lilienfeld, Turner, & Jacob, 1993; Taylor, Koch, Woody, & McLean, 1996; Zinbarg, Barlow, & Brown, 1997). AS has been conceptualized as a trait–like quality that amplifies pre–existing anxiety such that individuals are more likely to interpret physical symptoms as being harmful. Individuals with high levels of AS are more likely to have amplified fear responses to anxiety–provoking stimuli as well as become more frightened of their own anxiety symptoms (Reiss, 1991). Recent debate over the dimensional (Broman–Fulks et al., 2008; 2010) or categorical (e.g., Bernstein et al., 2006; 2007; Zvolensky, Forsyth, Bernstein, & Leen–Feldner, 2007) make–up of AS has emerged; however, contemporary literature indicates that AS is a dimensional construct (e.g., Asmundson, Weeks,

Carleton, Thibodeau, & Fetzner, 2011) as originally conceptualized (Reiss & McNally, 1985).

AS has received considerable empirical attention for its relationship with certain anxiety disorders, such as panic disorder (for review see McNally, 2002); more recently, AS has also been identified as a vulnerability factor for PTSD (Asmundson & Stapleton, 2008; Collimore, et al., 2008; Feldner, Lewis, Leen–Feldner, Schnurr & Zvolensky, 2006; Lang, Kennedy, & Stein, 2002; Stephenson, Valentiner, Jumpula, & Orcutt, 2009). AS dimensions have been found to be differentially related to PTSD symptom clusters; specifically, reports have independently recognized AS cognitive dyscontrol (Lang et al., 2002), and somatic concerns (Asmundson & Stapleton, 2008; Collimore et al., 2008; Fetzner et al., 2011), as well as both cognitive and somatic concerns concurrently (Feldner et al., 2006; Stephenson et al., 2009) as being the most robust predictors of PTSD symptom severity.

Reductions in AS have been found to account for reductions in anxiety and depression among clinical and community populations participating in regular aerobic exercise regimens (Smits et al., 2008). Higher intensity aerobic exercise programs (e.g., 20 minutes at 70% of maximum heart rate) have been found to be more effective than low–intensity aerobic exercise (e.g., walking) in the reduction of fears of bodily sensations (Broman–Fulks et al. , 2004; Smits et al., 2008). Similar to the anxiety reduction techniques often employed in cognitive behavioral therapy (i.e., exposure to feared physiological sensations), aerobic exercise has been shown to engender reductions in all three AS dimensions (Broman–Fulks & Storey, 2008). A small body of recent research has provided preliminary support for aerobic exercise as an effective treatment

for the reduction of AS (Broman–Fulks et al., 2004; Broman–Fulks & Storey, 2008; Smits et al., 2008).

The principle hypothesis for the evidence of reduced AS is that aerobic exercise involves exposure to physiological sensations similar to that of anxiety reactions (e.g., elevations in heart rate, muscle tension, shortness of breath, and sweating [APA, 2000]) and has been noted as a type of interoceptive exposure that facilitates exposure to feared bodily sensations. As individuals with anxiety disorders have been noted as having elevations in fears surrounding such bodily sensations based on the appraisal of catastrophic consequences (Fetzner et al., 2011), repeated exposure to such sensations may facilitate habituation and extinguish such fears. As well, repeated physical activity may also facilitate reductions in avoidance behaviour by facilitating cognitive corrections regarding the threatening nature of physical sensations brought on by physical exercise. Indeed, avoidance of physical exertion by individuals with anxiety disorders is common and has been conceptualized as a phobic behaviour serving to maintain and reinforce anxiety symptoms (Broocks et al., 1998). Repeated physical exercise therefore facilitates exposure to activities formerly avoided for fear of interoceptive cues, social interaction, and a host of other anxiety provoking stimuli. Furthermore, chronic exercise has been found to change the physiology of the body so that physiological arousal will be less marked during stressful situations (for review see Salmon, 2001) further reducing the likelihood of catastrophic interpretations of bodily sensations.

Contemporary cognitive behaviour therapy protocols for anxiety disorders typically involve therapeutic techniques, known as interoceptive exposure (see Appendix A for examples of IE exercises), which expose individuals to feared bodily sensations

similar to those encountered during anxiety responses (Broman–Fulks et al., 2008). Repeated exposure to such sensations facilitates habituation and may reduce catastrophic interpretations by demonstrating their innocuousness. Aerobic exercise may therefore constitute a type of interoceptive exposure as it involves similar changes in physiological status to that of anxiety reactions such as elevations in heart rate, muscle tension, shortness of breath, and sweating. Indeed, aerobic exercise has been posited as being a possible alternative mode of improving anxiety symptoms through similar processes (Wald & Taylor, 2008). Chronic exercise has also been found to reduce the likelihood of physiological arousal to stressful situations and consequently catastrophic interpretations of physiological sensations (Clark, 1986).

Interoceptive exposure is postulated to exert its therapeutic effect by targeting AS, which has been found to contribute to anxiety reactions, through repeated exposure to feared bodily sensations (Beck et al., 1997). More specifically, individuals with anxiety disorders, including PTSD (Van Ommeren et al., 2002), have been found to be more attuned to changes in physiological homeostasis and more likely to interpret unpleasant physiological sensations as being harmful (Leong Lim et al., 2008). As such, the aim of IE is to facilitate habituation of such bodily sensations through the reduction of AS (Goldstein & Chambless, 1978; Schmidt & Trakowski, 2004).

Research examining the utility of interoceptive exposure for anxiety disorders has emerged in recent years providing evidence for its use in clinical settings. Initially, interoceptive exposure was employed to treat panic disorder (Arntz, 2002; Barlow, Groman, Shear, & Woods, 2000; Craske, Rowe, Lewin, & Noriega–Dimitri, 1997; Taylor, 2000); although, more recently it has been used in the treatment of PTSD (Wald

& Taylor, 2005, 2007, 2008; Wald, Taylor, Chiri, & Sica, 2009). Interoceptive exposure may represent an effective alternative to trauma–related exposure therapy for individuals receiving treatment for PTSD. In particular, interoceptive exposure may be particularly helpful for clients exhibiting strong avoidance behaviours and as such may not be suitable for traditional trauma–related exposure therapy (Wald et al., 2009). Alternatively, interoceptive exposure's therapeutic benefits may bolster chances of success during future *in vivo* exposures by targeting fears of physiological sensations and AS, thereby making it more likely for clients to complete treatment (Wald & Taylor, 2008). Given the similarities between interoceptive exposure, aerobic exercise may also hold similar promise.

2. Current Study

2.1 Purpose

Research has provided preliminary optimism that aerobic exercise can effectively treat anxiety disorders (e.g., Broman–Fulks, et al., 2004) and associated risk factors such as AS (Smits et al., 2008); however, few studies (i.e., Diaz & Motta, 2008; Manger & Motta, 2005; Newman & Motta, 2007) have investigated its potential to reduce PTSD symptoms. Past studies have found that aerobic exercise is effective in reducing PTSD among adolescent female participants (Manger & Motta, 2005; Newman & Motta, 2007) and adults with a heterogeneous trauma history (Diaz & Motta, 2008). These studies are, however, limited by focusing primarily on children and adolescents, and administering a non–standardized exercise protocol, utilizing small convenience samples, and failing to examine mechanisms responsible for the therapeutic effects of exercise. The most common hypothesis to explain the anxiolytic effects of aerobic exercise is that exposure

(and eventual habituation) to feared somatic sensations (similar to that of interoceptive exposure therapy) accounts for reductions in anxiety. Although plausible, this hypothesis remains to be empirically tested.

The current study assessed the anxiolytic potential of a brief (i.e., 2 week) aerobic exercise regimen for reducing PTSD symptoms. In addition to adding to the dearth of studies in this avenue of research, limitations in previous research were addressed. First, anxiolytic mechanisms were tested by manipulating the participant's cognitive focus during exercise in order to test whether increased exposure to feared bodily sensations brought on by aerobic exercise precipitates additional therapeutic gains. In addition, the current study assessed participants' physical fitness and several psychological mechanisms hypothesised to account for the therapeutic effect of aerobic exercise (e.g., reductions in AS, eliciting of trauma–related memories). The current study also utilized an intent–to–treat, randomized controlled trial design, and implemented up–to–date statistical procedures employed in treatment research. Study participants were randomly divided into three groups that performed identical physical exercise programs, but different attention tasks while exercising to manipulate participants' focus on the anxiety–like sensations brought on by aerobic exercise. Group one (interoceptive exposure) was provided interoceptive prompts while exercising, group two (cognitive distraction) performed a cognitive distraction task, and group three (exercise only) performed exercise without any additional tasks.

2.2 Hypotheses

1. Participants, regardless of group membership, will report a statistically significant reduction in PTSD symptoms, AS dimensions, and depressive symptoms over the course of the six sessions of treatment and at follow–up.
2. Participants in the interoceptive prompts group will report statistically significantly lower PTSD symptoms, AS dimensions, and depressive symptoms than the cognitive distraction and exercise only groups after session six and at follow–up.
3. Participants in the interoceptive prompts group, but not the cognitive distraction or exercise only groups, will have clinically significant reductions in PTSD symptoms after session six and at follow–up.
4. Participants in the interoceptive prompts group, but not the cognitive distraction or exercise only groups, will demonstrate statistically significant reductions in trauma–related memories brought on by the physical exercise.

2.3 Participants

Consistent with Consolidated Standards of Reporting Trials (CONSORT) guidelines a figure detailing the participant flow through the study is presented in section 3.1. Fifty–seven participants expressed interest in participating in the current study; however, 11 (19%) were excluded due to ineligibilities identified in the online screen. Forty–six participants met all necessary criteria for the study in the online screen, but 13 (28%) were excluded in a phone screen leaving a total of 33 participants (58% of individuals who expressed interest in the study) who were admitted into the study. Study participants were mostly women (76%) and reported a mean age of 36.9 years (*SD* = 11.18 years; median age = 38 years; range: 18 to 60 years). Participants reported their

employment status as being either employed full time (46%), a student (24%), employed part time (12%), on leave from their occupation for medical reasons (6%), or not employed (6%). In terms of ethnicity, participants reported being Caucasian (79%), First–Nations (9%), Asian (6%), and Latino (3%). Participants also reported their highest education as having completed some university without graduating (36%), completed a graduate degree (24%), completed university bachelor's degree (12%), graduated high school (12%), and completed college diploma (9%).

2.3.1 Eligibility criteria. Each participant met criteria for either full or subsyndromal PTSD on both an online screen and phone interview conducted by the primary researcher. Participants were screened out if they were experiencing a substance use disorder, manic episode, serious suicidal ideation, or psychotic disorder; however, no participants were screened out on this basis. Participants were also screened out if they identified their PTSD symptoms as being anything but the primary source of distress and impairment in their lives. Participants were required to be free of or on a stable dose (on the same dosage for longer than 6 months) of psychopharmacological medication throughout the duration of their participation in the study. Interested individuals who were currently seeking psychotherapy were asked to focus on their current treatment and to inquire about participation in the current study once their psychotherapy was complete. Participants were denied entry into the study if a physical injury or condition (e.g., arthritis) that could potentially worsen if engaged in physical exercise was endorsed. Age restrictions for the current study were from 18 to 65 years.

2.4 Psychological and Lifestyle Measures

2.4.1 Traumatic Life Events Checklist (TLEC; Carleton, Brundin, Asmundson, & Taylor, unpublished measure; See Appendix B). The TLEC queries exposure to 16 potentially traumatic events (e.g., natural disaster, motor vehicle accident, sexual assault) commonly reported by community members. The TLEC also includes one open–ended *Other* question, where respondents can report any other traumatic events not covered by the checklist. If respondents indicate that they have been exposed to multiple traumatic events, they are asked to indicate the event that was the most distressing. Thereafter, the respondent is queried regarding when the event first occurred, and in the case of repeated exposure, when the event most recently occurred. Respondents were also asked if they experienced a sense of "intense fear, helplessness, or horror" as a result of exposure to the specific event. In addition to traumatic events meeting DSM–IV–TR (APA, 2000) Criterion A1 (e.g., *being assaulted*), three negative social events were included (i.e., "being publicly humiliated [worse than others]", "being severely bullied [worse than others]", and "being ridiculed [very badly teased, worse than others]") based on previous reports describing salient PTSD symptoms arising as a result of such experiences (e.g., Collimore, Carleton, Hoffman, & Asmundson, 2010; Fetzner et al., 2011; Fetzner, Horswill, Boelen, & Carleton, in press). TLEC data was used to characterize the sample, and was only administered in the online screen measures.

2.4.2 Posttraumatic Stress Disorder Checklist – Civilian (PCL–C; Weathers, Litz, Herman, Huska, & Keane, 1994; See Appendix C). The PCL–C is a 17–item self–report measure designed to correspond to PTSD symptoms as outlined in the DSM–IV–TR (APA, 2000). Items assess past month distress arising from traumatic exposure using 5–point Likert scale anchored from 1 (*not at all*) to 5 (*extremely*). The PCL–C provides

individual subscale scores corresponding with the three PTSD symptom clusters defined by the DSM–IV–TR (APA, 2000; re–experiencing, avoidance/numbing, hyperarousal); however, based on contemporary literature (Asmundson, et al., 2000; King et al., 1998; Shelby et al., 2005) and novel symptom structure of DSM 5 (APA, 2013), the current study considered avoidance and numbing as separate symptom clusters. The PCL–C has demonstrated high diagnostic efficiency (i.e., .90; Blanchard, Jones–Alexander, Buckley, & Forneris, 1996) as well as good test–retest reliability (i.e., .96; Weathers et al., 1994).

Investigation into appropriate cut–off scores for the PCL–C revealed that the sensitivity and negative predictive power of a specific cut–off score increases as the minimum score per item to meet diagnostic criteria rises from one to five while at the same time the specificity and positive predictive power falls (Ruggiero, Del Ben, Scotti, & Rabalais, 2003). The current study utilized best–practice guidelines proposed by the National Center for PTSD (2007) for assessment of PTSD symptoms using the PCL–C total scores among civilian populations; a cut score of 45 has been found to have good diagnostic efficiency throughout contemporary research using the PCL–C (e.g., Adkins, Weathers, McDevitt–Murphy, & Daniels, 2008; Andrykowski et al., 1998). In addition, the current study also assessed PTSD symptoms at the PCL–C item level to remain consistent with DSM–IV–TR diagnostic criteria (Asmundson, Norton, Allerdings, Norton, & Larson, 1998; Falsetti, Resnick, Resnick, & Kilpatrick, 1993). As such, PTSD caseness were defined by PCL–C scores meeting or exceeding 45, and endorsement of at least one item from criterion B, three items from Criterion C, and two items from criterion D. Items were considered endorsed when rated as moderately severe or worse (i.e., 3 or greater out of 5 on the Likert scale). Subsyndromal PTSD caseness were

defined by scores below 45 on the PCL–C (Blanchard et al., 1996), and endorsement of two items from criterion B, C, or D according to the definition of endorsement described above. The PCL–C was administered at each data collection point throughout the study and was used to characterize the sample, determine participant eligibility, as well as provide outcome data as participants proceeded through the intervention and follow–up phases.

2.4.3 Anxiety Sensitivity Index – 3 (ASI–3; Taylor et al., 2007; See Appendix D). The ASI–3 is an 18–item self–report measure designed to assess the tendency to fear anxiety–related sensations based on the belief that they have harmful consequences. Each item is rated using a 5–point Likert scale ranging from 0 (*agree very little*) to 4 (*agree very much*). Results of factor–analytic studies of the ASI–3 indicate that it comprises three dimensions, including fears of somatic sensations, cognitive dyscontrol, and socially observable symptoms, all loading on to a single higher–order factor of AS (Taylor et al., 2007). The validity and reliability of the ASI–3 has been well established (Taylor et al., 2007). The ASI–3 was employed at each data collection point throughout the study and was used to provide outcome data as participants proceeded through the intervention and follow–up phases.

2.4.4 Center for Epidemiological Studies – Depression Scale (CES–D; Radloff, 1977; see Appendix E). The CES–D is a 20–item measure designed to assess current (i.e., within the past week) depressive symptoms. Items are rated on a 4–point Likert scale ranging from 0 (*rarely/none of the time*) to 3 (*most/all of the time*). The CES–D has demonstrated acceptable internal consistency ($\alpha > .84$), test–retest reliability (*r*'s ranging from .49 to .67; Radloff, 1977), and convergent validity with other measures of

depressive symptoms (e.g., Hamilton Rating Scale for Depression [$r > .50$]; Devins & Orme, 1985). The CES–D was employed at each data collection point throughout the study and was used to characterize the sample and provide outcome data as participants proceeded through the intervention and follow–up phases.

2.4.5 Fantastic Lifestyle Questionnaire (Wilson, 1985; See Appendix F). The Fantastic lifestyle questionnaire is a 25–item measure used to assess lifestyle factors in individuals planning to begin a physical exercise regimen. Items assess lifestyle factors in areas of family and friends, activity, nutrition, tobacco toxins, alcohol, sleep, seatbelts, stress, safe sex, affective behaviour types, insight, and career. The measure was used to gain a multifaceted overview of each participant; however, only lifestyle variables pertaining to stress and activity were retained for the current study. The Fantastic lifestyle questionnaire was administered to participants during the online screen, and follow–up portions of the current study.

2.4.6 Stages of Change Questionnaire (SCQ; Gledhill, 2004; See Appendix G). The SCQ is a brief measure designed to identify a participant's willingness and thought processes regarding changes in his or her physical activity level. The measure includes two items assessing level of current and past levels of physical activity, as well as plans to engage in future physical activity. The SCQ was used to characterize the study sample prior to admission into the study and was only administered at the pre–treatment online screen.

2.4.7 Healthy Physical Activity Participation Questionnaire (HPAPQ; Gledhill, 2004; See Appendix H). The HPAPQ is a commonly used measure designed to assess participants' current physical activity levels. The measure includes three items

assessing frequency and intensity of current physical activity, as well as current perceived fitness levels. The first two items use a 3–point forced–choice answer format, whereas the third item uses a 5–point forced–choice answer format. The HPAPQ was used to characterize the study sample and was administered to participants during the online screen and follow–up portions of the current study.

2.4.8 Physical Activity Readiness Questionnaire (PAR–Q; Chisholm, Collis, Kulak, Davenport, & Gruber, 1975; See Appendix I). The PAR–Q is a 7–item self–report measure that assesses physiological readiness for participation in physical exercise. The PAR–Q asks several questions regarding cardiac problems, chest pain, high blood pressure, dizzy spells, joint problems, and other concerns that may prevent participants from engaging in physical activity. A positive response to any item on the PAR–Q results in failure and suggests an inability to participate in physical activity. If participants endorsed any item on the PAR–Q, they were required to have their doctor or other qualified physical health professional conduct an additional screen in order to participate in the current study. The PAR–Q was used to exclude ineligible participants during the online screen.

2.5 Exercise Session Response Questions

Immediately following each exercise session, participants were asked to rate their subjective experiences during the exercise session. Domains in which participants rated their experience were rated on a 11–point Likert scale ranging from 1 (*not at all*) to 11 (*very much*). Topics including motivation ("how motivated are you to continue to participate in the current study?"), difficulty of sessions ("how difficult did you find the exercise that you just completed?"), enjoyment ("how enjoyable was the exercise session

you just competed?"), eliciting of trauma memories ("how much did the exercise you just completed elicit memories of your index trauma?"), and focus on physical sensations ("how much did you think about the physical sensations that were brought on by the exercise during your session?").

2.6 Phone Screen Measures

2.6.1 Structured Clinical Interview for DSM–IV Axis I Disorders – Research Version; PTSD section

(SCID–I; First, Spitzer, Gibbon, & Williams, 2000). The SCID–I PTSD is a portion of the full Structured Clinical Interview for DSM–IV Axis I Disorders, which is a semi–structured clinical interview designed to assess for the presence of mental disorders. The SCID–I PTSD section includes 25 questions assessing DSM–IV–TR PTSD criteria as well as assessing the individual's trauma history and establishing a reference trauma for preceding posttraumatic symptomatology. Questions are administered verbally to respondents so that elaboration and clarification is possible. Item responses are rated by the administrator as *yes/no* or *indeterminate* if a concrete answer is unable to be obtained. In order to meet criteria for PTSD, the respondent was required to endorse (1) a history of at least one traumatic experience, during which he or she experienced intense fear, helplessness, or horror, together with (2) at least one re–experiencing symptom (e.g., "did you think about [TRAUMA] when you did not want to or did thoughts about [TRAUMA] come to you suddenly when you didn't want them to?"), (3) three avoidance/numbing symptoms (e.g., "have you made a special effort to avoid thinking or talking about what happened?"), and (4) two hyperarousal symptoms (e.g., "have you had trouble sleeping?"). Information gathered from the SCID–I PTSD section was used to ensure participants meet criteria for full or subsyndromal PTSD. Like

the PCL–C, subsyndromal PTSD was characterized by the endorsement of two symptoms of re–experiencing, avoidance/numbing, and hyperarousal symptom clusters. The SCID–I PTSD section was only administered during the pre–treatment phone screen.

2.6.2 MINI International Neuropsychiatric Interview Screener Modified (See Appendix J). The MINI–screener is an interview–based checklist of screener questions for various mental disorders. The MINI–Screener Modified includes 15 questions, 14 of which are rated on a *yes/no* basis. The first 14 questions screen for symptoms typical of common Axis I disorders including depression, mania, panic disorder, social anxiety disorder, generalized anxiety disorder, obsessive compulsive disorder, PTSD, alcohol–related disorders, other substance–related disorders, eating disorders, and suicidal ideation. Endorsement of suicidal ideation prompted the administration of further screening procedures for suicide risk (described below). The last question provides respondents an opportunity to indicate which reported symptoms cause them the most distress, thereby assessing which disorder is likely primary and secondary. The MINI–screener has been found to have the ability to screen out patients without disorders, detect patients with a disorder, and is useful in both clinical psychiatry and research settings (Sheehan et al., 1998). Answers provided from both the SCID–I PTSD section and MINI–screener were used to determine participant eligibility and characterize mental disorder comorbitity in the current sample. The MINI–screener was only administered during the pre–treatment phone screen.

2.6.3 Beck Suicide Severity Inventory (BSSI; Beck & Steer, 1993). The BSSI was used on an as–needed basis during the phone screening procedure of participants. If an individual admitted to a recent history of or current suicidal ideation, attempts, or self–

harming behaviour during the MINI–screener, the BSSI was administered to assess risk and the need to refer individuals to other safety resources (e.g., Regina Mobile Crisis Hotline). The BSSI can be administered directly to participants or one–on–one with a trained administrator. The inventory consists of 21 items assessing multiple dimensions of suicidality (i.e., characteristics of attitudes toward living/dying; characteristics of suicide ideation/wish; characteristics of contemplated attempt; current status of suicidality; actualization of contemplated attempt; background factors). Each item is rated on a 3–point Likert scale ranging from 0 to 3; all items with the exception of background factors are totalled to reveal a score of suicide potential. There is no specific cut–off point for the BSSI; higher scores reflect an increased suicide risk (Beck and Steer, 1993). Decisions on whether or not to escalate safety measures for individuals endorsing suicide risk in the current study were made on a case–by–case basis. Three participants were screened for suicide risk using the BSSI; each of these participants was deemed to have mild to no risk for suicidal behavior (e.g., the participant admitted that they have no intentions of ever committing suicide but occasionally think about death).

2.7 Physical Testing Procedures

Three separate methods were used to assess physical fitness in the current study. First, a YMCA ergometer bike test was employed to assess participant's aerobic fitness level. The YMCA ergometer bike test is a submaximal exercise test which uses a cycle ergometer to estimate VO_2 maximum for men and women. The protocol uses three or more consecutive three minute workloads that are designed to raise the participant's heart rate to between 110 beats per minute and a heart rate that is near 85% of the age–predicted heart rate maximum for two consecutive workloads. Participants are required to

pedal at a rate of 50 rpm and the initial workload is 25 watts. The heart rate during the last minute of the first workload determines the loading sequence for subsequent workloads. The YMCA test uses an "extrapolation" method in which heart rate–workload points are obtained and extrapolated to age–predicted maximal heart rate. This method predicts the workload at the maximal heart rate and VO_2 maximum is then predicted from the predicted maximal workload. Submaximal exercise tests that predict VO_2 maximum have been found to be reliable tools to assess cardiovascular fitness level (e.g., Beekley et al., 2004). Furthermore, the YMCA test has been used to gauge the aerobic fitness capabilities (e.g., Hansen, Stevens, & Coast, 2001) and progression (e.g., Long, 1983) of individuals participating in conditioning programs aimed at increasing cardiovascular fitness while simultaneously decreasing general indicators of psychological stress and negative mood states.

The second method used to assess physical fitness was a six–point skinfold measurement designed to assess body fat percentage. Skinfold measurements were taken from the tricep, subscapular, iliac crest, abdominal, chest, and front thigh. Two skinfold measurements were taken from each location and averaged in order to obtain consistency of measurements. The averages of all six locations were summed and applied to the following formula (Watts, Stewart, Birch, & Bernier, 2006). Skinfold measurements have been found to be a reliable and valid index of obesity, which corresponds with decreased physical activity, muscle strength, and aerobic fitness capacity (Duvigneaud et al., 2008). High skinfold measurements have also been found to directly associate with decreases in aerobic fitness capacity (Buffart, van den Berg–Emons, van Wijlen–Hempel, Stam, &

Roebroeck, 2008). The formulae for obtaining body fat percentages from participants are as follows:

Men aged 18 to 30 years:
([sum of 6 measurements] x .097) + 3.64

Men aged 30 years and older:
([sum of 6 measurements] x .1066) + 4.975

Women aged 18 to 30 years:
([sum of 6 measurements] x .217) + 4.47

Women aged 30 years and older:
([sum of 6 measurements] x .224) + 2.8

Lastly, resting heart rate was assessed in order to assist in the obtaining of target heart rate reserve ranges which participants would be required to exercise at throughout the duration of the study. Resting heart rate was assessed using a mechanical blood pressure cuff and confirmed by the attending certified personal trainer research assistant. Heart rate reserve ranges were calculated by obtaining 60% to 80% of the participants' maximal heart rate which utilized the following formula:

(220–age of participant) – (resting heart rate).

2.8 Equipment

All exercise sessions were completed on a stationary bicycle (Keiser M3). The bicycle could be adjusted to meet the physical stature of the participant and had an optional gel seat to make exercise more comfortable. Participants' heart rate and repetitions per minute were displayed on a digital display in front of them. Each participant was required to wear a heart rate monitor which was attached to their iliac crest using an elastic strap.

2.9 Trial Design, Setting, and Target Population Availability.

The current study design was a single center, balanced randomisation (1:1:1), single blind, parallel–group study conducted entirely at the University of Regina Anxiety and Illness Behaviours Laboratory in Regina, Saskatchewan, Canada. Data collection for the current study commenced in August 2012 and completed December 2012. Regina, is the second largest city in Saskatchewan, and the eighteenth largest in Canada according to 2011 census data (Statistics Canada, 2011), with a population of approximately 193,100. Prevalence rates of PTSD within the Regina area population are unavailable; however, based on Canadian population data (Van Ameringan et al., 2008), it is estimated that 17,765 individuals in the Regina area may be affected by PTSD symptoms at some point during their lifetime.

2.10 Procedure

Advertising for the current study occurred in a number of mediums, including free online advertisements (kijiji, usedregina.ca), website features (University of Regina and Anxiety and Illness Behaviours Laboratory websites), radio features (Canadian Broadcasting Corporation Regina Radio One, Regina Community Radio), television stories (Global News Regina), and print news (the Regina Leader Post). Additional participants were recruited by accessing local psychologists' and psychological service waitlists, and from other studies screening out participants with clinically significant PTSD symptoms. All individuals interested in participating were required to complete an online screening questionnaire housing measures assessing eligibility criteria for the current study (i.e., TLEC, PCL–C, ASI–3, CES–D, SCQ, Fantastic Lifestyle Questionnaire, HPAQ, PAR–Q). Once complete, potential participants provided contact information so that they could be contacted and interviewed to ensure study eligibility.

Only individuals meeting probable criteria for full or subsyndromal PTSD were contacted by phone; other individuals were emailed and notified of their ineligibility. The purpose of the phone screen was to confirm the presence of full or subsyndromal PTSD, to screen out any individuals not meeting eligibility criteria, and to schedule the participant's six exercise sessions.

Once entered into the study, participants were randomized into one of the three study groups (see section 2.10.4). Thereafter, each participant was sent an email three days prior to their first session. The email contained two links, the first of which directed participants to an online survey housing measures identical to that which they were to complete after each exercise session (i.e., PCL–C, ASI–3, CES–D, exercise session response questions); the second directed participants to a 5 minute online video specific to their study group. Videos provided participants with brief psychoeducation on PTSD symptoms, details for participation (e.g., how hard participants should exercise), directions to the laboratory, and brief methodology rational. Group videos differed only in description and rational of the attention task to be completed during exercise. Videos were 5 minutes and 17 seconds (exercise only), 5 minutes and 49 seconds (cognitive distraction), and 5 minutes and 53 seconds (interoceptive prompts) in length.

During the participants' initial visit to the laboratory, the primary researcher greeted the participant and answered any questions prior to beginning their physical testing and exercise session. Physical testing was completed prior to the actual exercise session, both of which were administered by a certified personal trainer research assistant. The research assistants were hired to ensure that the treatment protocols were being adhered to and that the participant was doing so safely. In most cases, one

participant was matched with one research assistant to follow him or her throughout the entire study. After the exercise was completed, participants were given five to ten minutes to cool–down and stretch. When ready, participants were directed to a computer housed within the exercise room to complete the same battery of measures completed three days prior to start the study. The research assistant exited the room once they began to complete the questionnaires. The subsequent five exercise sessions were identical to the first, with the exception of the absence of physical testing. Each participant completed the six exercise sessions in less than two weeks from their initial session, engaging in no more than four and no less than two sessions per week.

Once the in–lab treatment protocol was completed, participants were reminded of the follow–up measures and given the chance to ask any questions or raise concerns about the treatment protocol. Follow–up consisted of emailing participants links to an online questionnaire battery identical to the pre–treatment and each post–session battery at one week and one month after their last session. Additionally, participants were also asked to complete lifestyle questionnaires (i.e., Fantastic lifestyle questionnaire, HPAQ) in order to assess for any changes in physical activity engagement. Participants were asked to complete these measures within 24 hours of receiving the email. Participants were also given the opportunity to come back after one month and undergo another physical test, identical to that which they had completed on their first session. The purpose of the second physical fitness test was to assess for potential changes in physical fitness; however, no participants exercised this option.

2.10.1 Intervention groups. Participants in the current study were randomly assigned to one of three intervention groups: cognitive distraction, exercise only, and

interoceptive prompts. Each group was required to complete the same type of physical activity; however, the groups differed in the extent to which their cognitive attention was manipulated by the study protocol. To follow is a comprehensive outline of the similarities and differences between intervention groups.

2.10.1.1 ***Similarities between intervention groups.*** Processes involved in each treatment group were designed to be similar enough to ensure comparison across groups. Participants in each group were required to exercise from 60 to 80% of their heart rate reserve level, which was identified during the initial physical testing, for each of their six exercise sessions. Research assistants sat behind participants and only interacted when the study protocol required them to do so. Research assistant/participant interactions were standardized throughout the study such that, with the exception of asking participants to adjust their exercise workload, research assistants were only allowed to use several neutral phrases (i.e., "you're really working hard", "way to work", "good effort", "keep going", and "finish strong"). If the participants spoke to the research assistants for any purpose other than that which was germane to their continued participation in the exercise session (e.g., feeling dizzy and needing to stop the exercise), the research assistants would provide a reminder that they were unable to talk during their exercise. Standardization of research assistant/participant interaction ensured that participants were not receiving unintended encouragement throughout the study. Each exercise session was completed in the same exercise room, which was kept in the same order and design for each participant.

Although there are no specific mental health benefits of aerobic exercise which are not present among other forms of physical exercise (e.g., anaerobic exercise, cross–

training), aerobic exercise was chosen as the treatment modality for the current study due to the propensity of studies which have utilized aerobic exercise for treatments of other mental disorders (e.g., Broman–Fulks et al., 2008; Broocks et al., 1998; Martinsen et al., 1989; Smits et al., 2008; Wedekind et al., 2010). Indeed, anaerobic exercise has been used comparatively less and, as such, may represent an appropriate next step after completion of the current study. Furthermore, aerobic exercise allowed for more ease in standardizing the exercise while also implementing different tasks between groups.

A brief aerobic exercise protocol was chosen for the current study based on several seminal studies (i.e., Broman–Fulks et al., 2008; Smits et al., 2008) in the area of applying aerobic exercise protocols for reduction of mental health disorder symptoms and associated risk factors. Above and beyond the rational of extending past research, acute bouts of aerobic exercise have been noted to have positive mental health benefits. Acute bouts of aerobic exercise have been found to bring about positivity of affect, especially during recovery phases following exercise bouts involving high amounts of effort (Ekkekakis & Petruzzello, 199). Furthermore, reductions in mental disorder symptoms (e.g., generalized anxiety disorder; Herring et al., 2012) and risk factors (e.g., AS; Broman–Fulks et al., 2004; Broman–Fulks et al., 2008; Smits et al., 2008) have been recognized in exercise regimes lasting for as short as two weeks. Given the aforementioned findings, an acute bout of aerobic exercise was expected to be sufficient to produce detectable changes in PTSD symptoms among study participants.

2.10.1.2 ***Differences between intervention groups.*** The protocol goal for the cognitive distraction group was to shift the participants' attention away from the difficulty of the exercise and reduce the attention paid to the anxiety–like symptoms

brought on by the exercise. Distraction was accomplished by having participants in the cognitive distraction group watch a nature documentary (i.e., National Geographic's Untamed Americas) on a projection screen set up approximately three meters to the front. Participants were asked a series of three distracter questions at five minute intervals during their exercise session. Questions had to do with the content of the video they were watching (e.g., "how fast did the narrator say a wolf can run?") and ensured that the participants were focusing on the video and not the difficulty of the exercise. Lights were dimmed to bring the focus of the participants to the distraction video.

The protocol goal for the exercise only condition was to allow participants to exercise freely and to set their cognitive attention to wherever they chose. The exercise room was completely silent and no interaction between participants and research assistants occurred beyond when participants were reminded to exercise at the target heart rate reserve range. The projector screen set up in front of them was turned off and remained blank for the entire session. Participants were not allowed to use any type of entertainment device (e.g., MP3 player) which would provide distraction from the exercise protocol.

The protocol goal for the interoceptive prompts group was to bring the participant's attention to the difficulty of the exercise and the anxiety–like sensations brought on by the exercise as much as possible. This was achieved by having participants watch real–time video of him or herself on the projector screen set up in front of them. Additionally, every five minutes participants were given three interoceptive prompts bringing their attention to (1) the tightness in their leg muscles, (2) the tightness in their upper body, and (3) the difficulty of their breathing. After each interoceptive prompt, the

research assistants requested that the participants give a 0 to 10 rating on the intensity of each sensation, and spend ten seconds focusing on the sensation. Participants were not allowed to use any type of entertainment device (e.g., MP3 player) which would distract them from the exercise protocol.

2.10.2 Randomization sequence, generation, type, and implementation. An independent research group performed group randomization (cognitive distraction, interoceptive exposure, or exercise only) according to computerized random numbers. Group allocation was performed once screened individuals had been deemed eligible to participate in the study by the primary researcher. Allocation was requested by email and provided by request, one case per request.

2.10.3 Blinding. All study participants were blind to the existence of other intervention groups. Videos online were concealed from viewers outside those randomized to the specific study group by adjusting the privacy settings on the online video website (www.youtube.com); only those with the video link were able to access the video. This ensured that participants from other groups were unable to view the other intervention group videos by performing an internet search. Participants were also scheduled in the exercise room no less than 15 minutes apart; if they arrived early, or a session went late, they were instructed to wait in a waiting room with sufficient distance from the exercise room to preclude the possibility of distinguishing their group protocol from the other group protocols. To the best of the author's knowledge, active participants did not have any contact with one another throughout the duration of the in–lab portion of the study. Only one participant reported that they became aware of the existence of other study groups. Mean comparison suggested that this participant was no different in study

responses to that of the rest of the participants. Furthermore, the participant stated that his/her responses and behaviour during the treatment protocol was not affected by this knowledge.

Each research assistant was aware of the participants' group allocation because they were given the primary responsibility of ensuring adherence to protocol while in session. Research assistants were unaware of the participants' symptom presentation or trauma history as they were not involved in the screening procedure, self–report data collection, or data analytic process. Similarly, those involved in the screening procedure, self–report data collection, and data analytic process had minimal interaction with the participants during the treatment phase and follow–up phase. Contact between study researchers and participants were only made during the intervention phase when participants required rescheduling of events or when problems arose with participants' participation. This separation ensured no bias among those collecting and analysing the data.

2.11 Analytic Procedure.

Analyses for the current study were conducted using an intention–to–treat design. All participants who were randomly assigned to study groups were retained for analyses. The analytic procedure for the current study was broken into six phases: (1) description of participant flow, (2) descriptive statistics, (3) preliminary analyses, (4) primary statistical analyses, (5) secondary statistical analyses, and (6) assessments of clinically significant change. Due to the large number of analyses in the current study, efforts were made to reduce the chances of Type II error. As such, a bonferroni correction was utilized in all analyses of variance (ANOVAs); in all other analyses, the level of statistical

significance was adjusted from $p < .05$ to $p < .01$ (Westfall & Young, 2003), which is consistent with contemporary research on anxiety that performs many statistical analyses (e.g., Fetzner et al., 2013). To follow is a brief description of the statistical methods and rational for implementation in the current study.

2.11.1 Participant flow and sample size. Consistent with CONSORT guidelines, participant flow through the current study was described in terms of recruitment, screening, randomization, and treatment phases. Also consistent with CONSORT guidelines, a diagram was provided to outline the flow of participants. Data suitability for the current analyses is thereafter discussed.

2.11.2 Descriptive statistics. Prevalence of PTSD and depression were reported based on information gathered in the phone interview (SCID–II PTSD section and MINI–screener respectively) and data gleaned from the online screen (PCL–C and CES–D respectively). Descriptive statistics including comorbid mental disorders (MINI–screener) and self–reported physical fitness (Fantastic lifestyle questionnaire, HPAQ, SCQ) were also reported. Finally, trauma history gathered from the TLEC, including prevalence of indexed and endorsed traumas, was summarized.

2.11.3 Preliminary analyses. Preliminary analyses were run to assess for differences among groups and to investigate the treatment manipulation fidelity. First, to assess for potential intervention group differences during the online screen, a series of one–way between group ANOVAs were run; dependent variables included PCL–C total and subscale scores, ASI–3 total and subscale scores, CES–D total scores, motivation to participate, and estimated VO2 max scores. Second, to assess for potential baseline differences between completers and non–completers, a series of independent samples t–

tests were run; dependent variables included PCL–C total and subscale scores, ASI–3 total and subscale scores, CES–D total scores, motivation to participate, and estimated VO2 max scores. Third, to assess for potential differences between intervention groups in exercise response questions, a series of hierarchal linear models (i.e., hierarchal linear modeling [HLM]) were run in a similar fashion as the primary analyses (see section 2.11.4) utilizing each of the five exercise response questions as dependent variables and ratings gathered after session 6 as the intercept.

Effectiveness of treatment manipulation for the cognitive distraction and interoceptive prompts groups was assessed in two ways. For the cognitive distraction group, the average number of questions answered correctly was used as a metric of how effective the cognitive distraction task was at reducing participants' attention to the difficulty of the exercise. Higher numbers of correct responses were assumed to be indicative of increased attention paid to the video rather than to the difficulty of the exercise. Next, a series of paired samples *t*–tests were conducted to assess for potential changes in interoceptive prompt ratings from session 1 to 6. The analyses were run to gauge the effectiveness of the intervention at habituating the participants to the difficulty of the exercise.

In preparation for the primary statistical analyses, statistical analyses were conducted to discern for possible differences in screening and pre–treatment scores. More specifically, the decision to use pre–treatment scores as the baseline measure of primary outcome variables was made because 1) each participant completed the pre–treatment scores three days prior to their first session, and 2) each participant was aware that they would be participating in the current study, thus impression management factors were

likely less so than in the online screening measures. To ensure that study variable scores did not change markedly between the online screen and pre–treatment scores, paired samples *t*–tests were performed on PCL–C total and subscale scores, ASI–3 total and subscale scores, CES–D total scores, and motivation to continue with the study.

2.11.4 Primary statistical analyses. To examine the change in primary outcome variables (i.e. PCL–C total and subscale scores, ASI–3 total and subscale scores, CES–D scores, and trauma–related memories elicited by the exercise session) over time as a function of experimental condition, a two–level HLM approach was employed. Such an approach allowed for identification of outcomes for individuals over the course of the study, and differences among individuals in the intercept and slope to be determined by the specific experimental group. Similar methods of data analysis have been employed in recent randomized controlled trials (RCT; e.g., Arch et al., 2012; Deacon et al., 2012; Smits et al., 2008) and have been noted as being a reliable form of hypothesis testing for repeated measures and event histories (Schulz & Maas, 2010).

The primary advantage of HLM is its handling of missing data; specifically, HLM does not require each participant to be assessed at each time point. Notwithstanding, due to the amount of missing data (i.e., greater than 5% of individual data points) the current study employed recommendations to multiply impute missing data (see section 2.11.4.1) to avoid potential biases in the results (see Heck, Thomas, & Tabata, 2010 for discussion). Another advantage of HLM is that time points do not have to be taken at equal time intervals (Shin, 2009; Tabachnick & Fidell, 2013). This advantage fits well with the current data given that participants varied by one or two days on when they scheduled their sessions and when they completed their follow–up measures. HLM also

provides an increase in statistical power in determining whether or not a change has taken place (Shin, 2009; Willett, 1989). This is accomplished by treating each assessment for each participant as a single data point, rather than analyzing variance of means at specific time points as is the case with repeated measures ANOVA (Heck et al., 2010). HLM has also been proven effective for use with missing data points during follow–up periods (Shin, 2009), as is the case in the current study. A more detailed discussion on the advantages of HLM is available elsewhere (e.g., Heck et al., 2010; Tabachnick & Fidell, 2013).

2.11.4.1Missing data imputation. Missing data are a pervasive problem in data analysis of repeated measures and intent–to–treat designs. In essence, there is no way to ascertain the actual value of a missing data point; however, omitting such data may drastically reduce the statistical power of the analyses and potentially bias results. Unfortunately, there is no single agreed upon method for inferring missing data points; but, several methods have received more recent praise than others. Careful exploration of the available and missing data, as well as the nature of the data itself, may lead to more theoretically–sound approaches to choosing a data imputation method.

Although HLM is designed to deal with small amounts of missing data (i.e., less than 5%; Heck et al., 2010), the current data had approximately 24% missing data points. These missing data points were mostly congested around the follow–up period, whereas only 10% of data were missing in the study period, The amount of missing data in the current study is not uncommon for studies of this nature, wherein drop–out rates range from 18% to 31% (e.g., Broman–Fulks et al., 2008; Smits et al., 2008).

The current study followed best practice recommendations put forward by Kmetric, Joseph, Berger, and Treehouse (2002), wherein they suggested the utilization of multiple methods of data imputation to ascertain a greater picture of certainty regarding outcomes with missing data. Prior to utilizing any imputation method, the nature of the observed data and missing data in the current study was considered. In particular, the data in the current study were in a repeated measures design wherein assessments were made in sequential order. Continued adherence to the study protocol therefore meant that participants had to keep coming back into the laboratory to conduct the aerobic exercise sessions. In no case did a participant drop–out of the study and then return, and all study participants completed at least their first aerobic exercise session. Data points were also similar between participants, wherein each participant conducted the same task at each point in time. Given these data characteristics, imputing data in a way which takes into account (1) the trend of previously observed data from the individual participant, and (2) observed data from participants who behaved in a similar way at time points where the missing data exists may allow for optimal speculation on missing data.

Primary analyses utilized a predictive mean matching multiple imputation method (hereafter referred to as the predictive mean matching method). Multiple imputation has been hypothesized as being an effective method for imputing missing data for RCTs (Feilding, Maclennan, Cook, & Ramsay, 2008). This particular method of multiple imputation is effective because it allows for user–specified sets of covariates, which assist in the imputation of missing variables. The predictive mean matching method also allows for defining of cases which can be drawn from to impute missing values. In the current study, imputed values were drawn from the closest 10% of cases which were

most like the behavior of the participant prior to the missing data point. For comparative purposes, analyses were also conducted using data sets imputed by an alternative form of multiple imputation (mahalanobis distance matching method), single imputation (last–observation–carried–forward), and completers only (i.e., only analysing observed data points). Means of each data imputation method will be presented for each primary outcome variable for comparison purposes.

2.11.5 Secondary statistical analyses. Secondary analyses in the current study were designed to assess for changes in physical activity (i.e., Fantastic Lifestyle Questionnaire, HPAQ) among study participants once the study was completed. Differences in five self–reported domains of physical activity were assessed using paired samples *t*–tests. Self–report variables included (1) amount of vigorous activity engagement, (2) amount of moderate physical activity engagement, (3) intensity of physical activity engagement, (4) amount of physical activity engaged in the past week, and (5) general impression of physical fitness. Additionally, changes in exercise response questions (i.e., difficulty of exercise session, enjoyment of exercise session, motivation to continue the study, and amount of attention paid to physiological sensations brought on by the exercise) were analyzed with the same two–factor HLM structure employed in the primary analyses.

2.11.6 Assessing for clinically significant change. Clinically significant change was assessed for PTSD and depressive symptoms as well as AS severity over the course of the intervention. Clinically significant changes in PTSD was assessed by ascertaining the prevalence of participants reporting a 10 point (or greater) drop on the PCL–C (as suggested by the National Center for PTSD, 2007). Clinically significant changes in

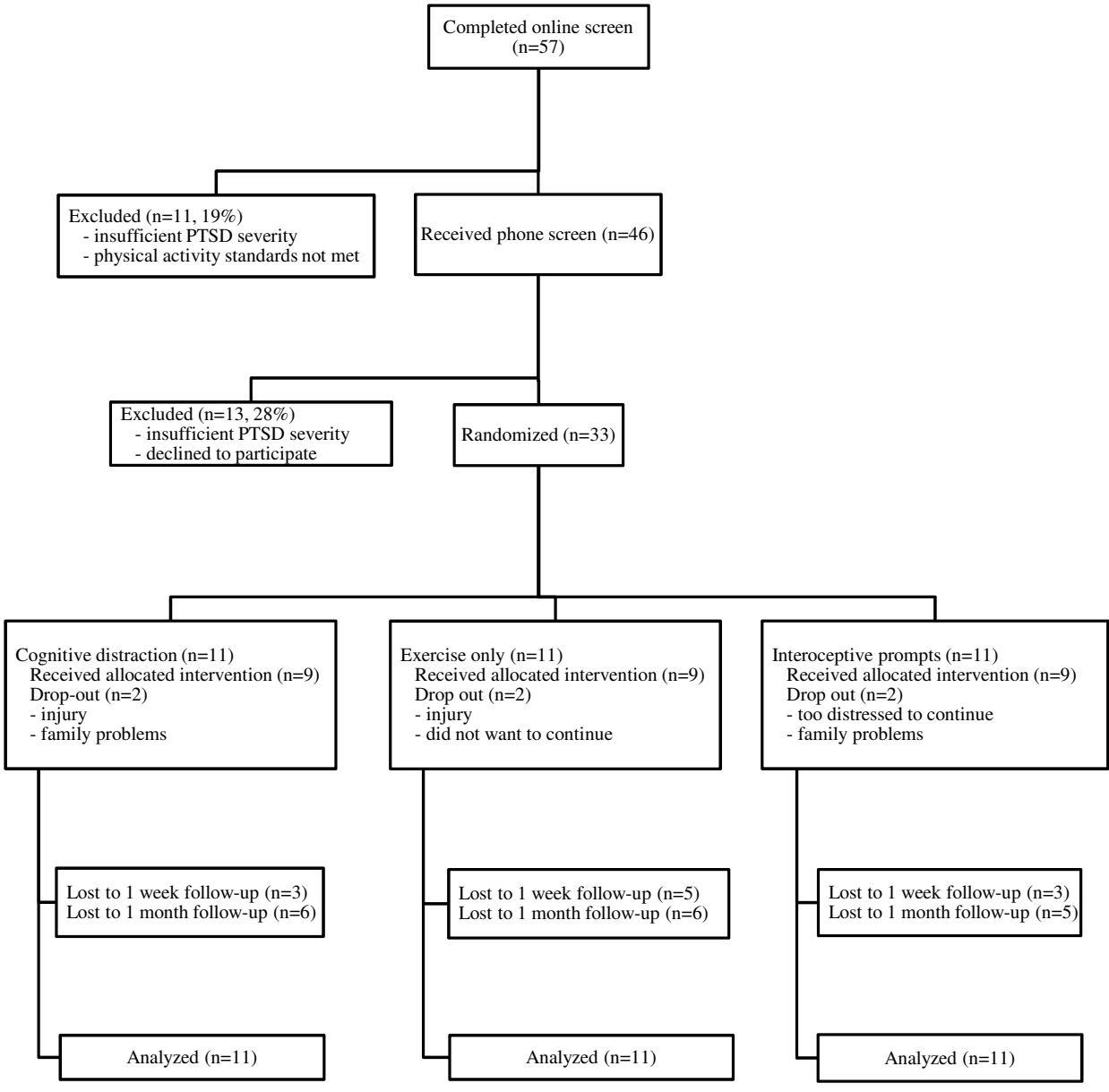
depressive symptoms and AS severity were assessed in a similar manner. Specifically, the prevalence of participants who evidenced CES–D and ASI–3 total score reductions over two standard deviations from pre–treatment scores was reported (Jacobson & Traux, 1990). Presentation of clinically significant changes followed the example of Smits et al., 2008 wherein percentages of participants in both intent–to–treat and completers samples are presented separately.

3. Results

3.1 Participant Flow

Progression of participants through the study is presented in Figure 1. A total of six participants (18%) dropped out of the study during the in–lab portion before completing the prescribed six aerobic exercise sessions (2 = cognitive distraction; 2 = exercise only; 2 = interoceptive prompts). Reasons given by participants for drop out in the cognitive distraction group included, “not wanting to continue with the study” and “family problems”. Reasons given by participants for drop out in the exercise only group included, “sustaining an injury” and “not being able to cope with the intensity of anxiety symptoms brought on by the physical exercise”. Reasons given by participants for drop out in the interoceptive prompts group included, “sustaining an injury” and “family problems”. Drop–out rates and sample size for the current study were consistent with other studies conducted in this area (e.g., Broman–Fulks et al., 2008; Smits et al., 2008).

Figure 1. Participant flow



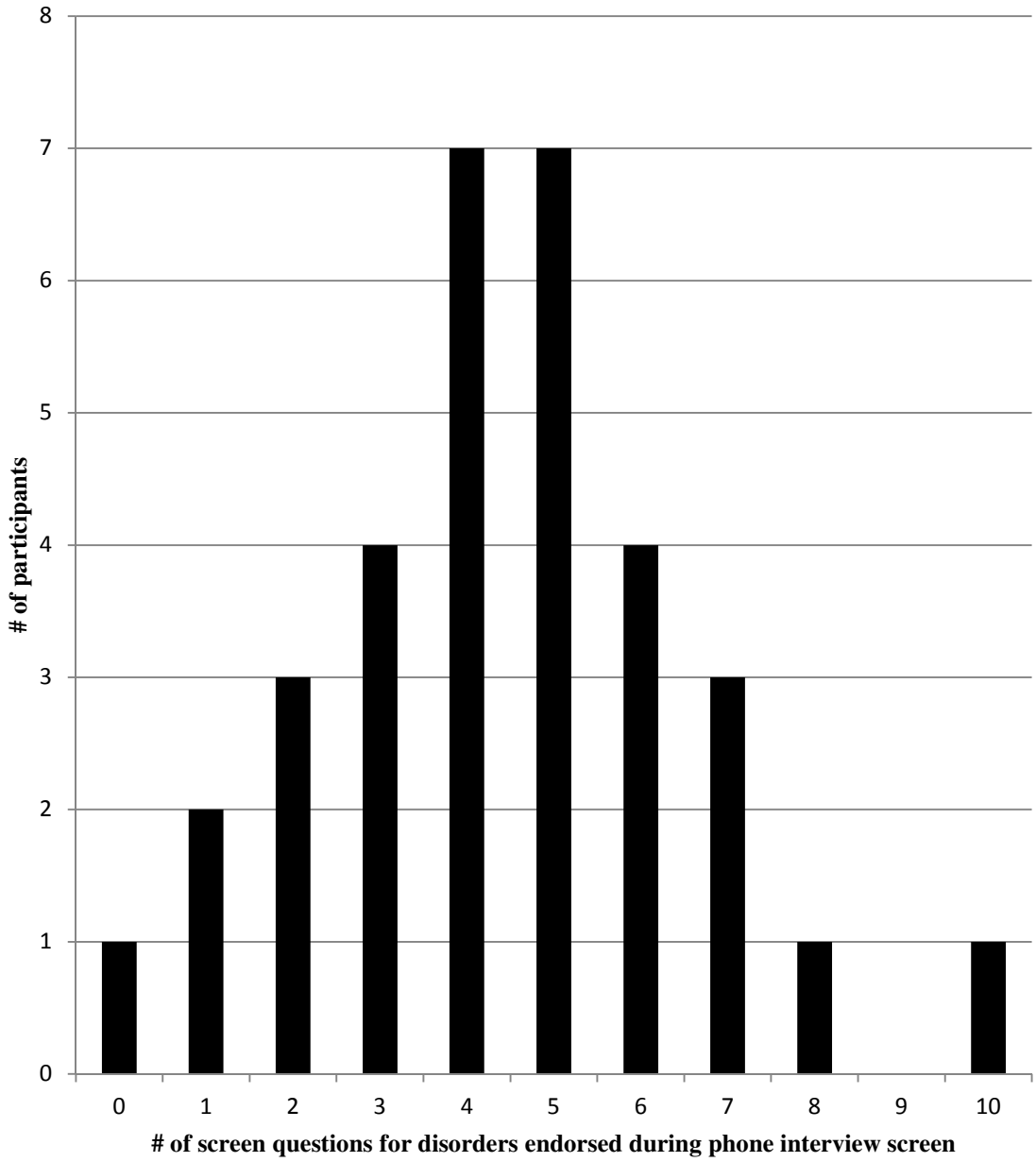
Note: PTSD = Posttraumatic stress disorder.

3.2 Descriptive Statistics

Comorbid mental health conditions experienced by the current sample are summarized in Figures 2 and 3. Participants in the current study reported a mean PCL–C score of 55 (*SD* = 12.73) in the online screen. Based on online screen scores and phone screen, 25 participants met criteria for PTSD (10 = cognitive distraction; 7 = exercise only; 8 interoceptive prompts), and 8 for subsyndromal PTSD (1 = cognitive distraction; 4 = exercise only; 3 = interoceptive prompts). CES–D scores obtained through the online screen suggested that each participant met criteria for probable depression. During the phone screen, however, five participants (1 = cognitive distraction; 3 = exercise only; 1 = interoceptive prompts) reported *not* having the necessary symptoms for a current major depressive episode diagnosis (i.e., depressed mood most of the day, nearly every day or markedly diminished interest or pleasure in all, or almost all, activates most of the day nearly every day; APA, 2013).

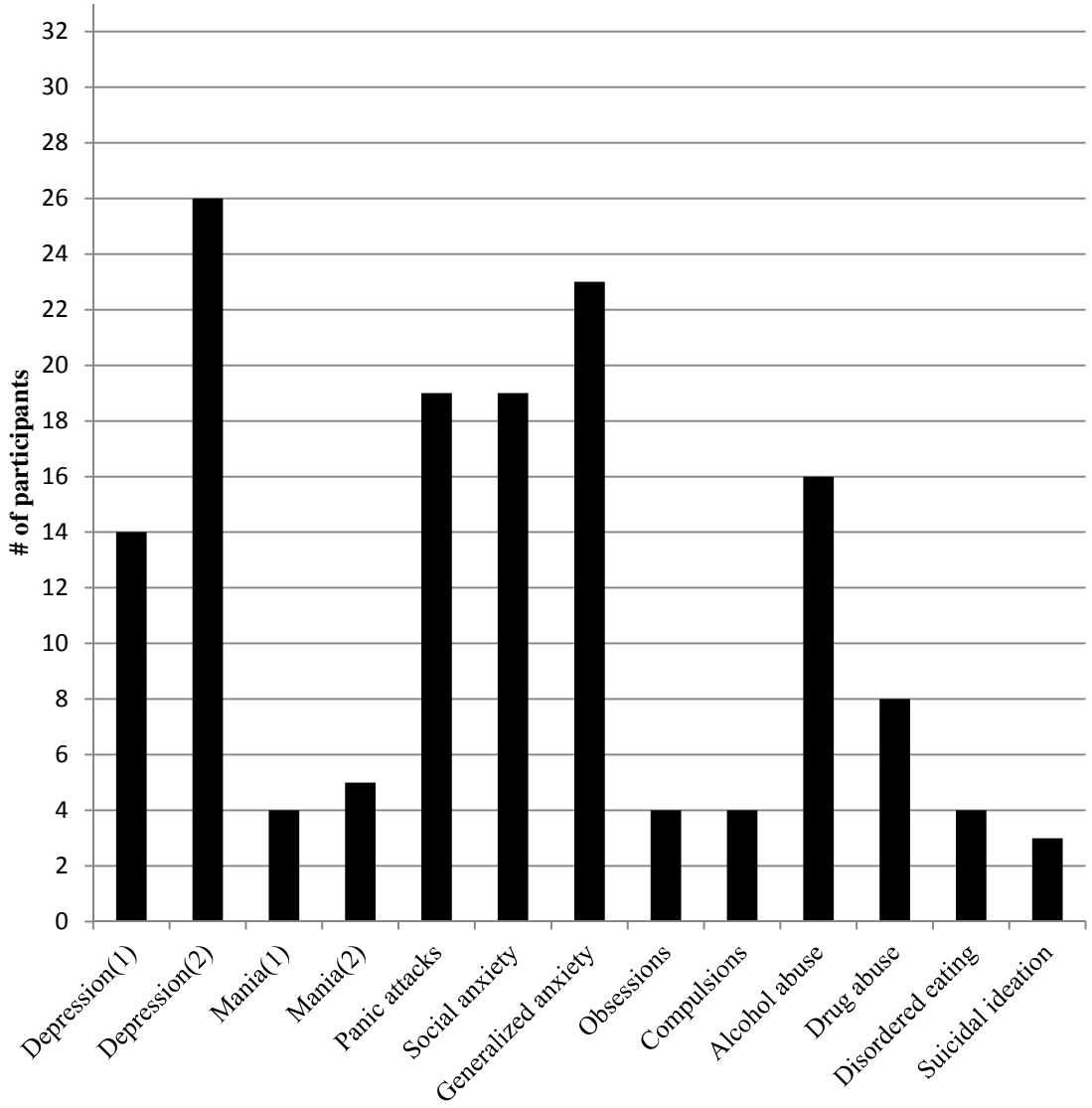
Other mental disorder symptoms endorsed during the phone screen in the study population included generalized anxiety (70%), panic attacks (58%), social anxiety (58%), alcohol abuse (48%), drug abuse (24%), single and multiple manic episodes (21%), obsessions (12%), compulsions (12%), disordered eating (12%), and suicidal ideation (9%). Only one participant reported only having PTSD without a comorbid condition. Each participant reported that their PTSD symptoms were primary to any of the other symptoms endorsed.

Figure 2: Number of screen questions endorsed to suggest comorbid disorders in the current sample.



Note: number of screen questions for disorders endorsed during the phone interview screen does not include posttraumatic stress disorder.

Figure 3: Comorbities of specific disorders in the current sample.



Note: Comorbidities were assessed by the MINI–Screener. Depression(1) = participant reported being consistently depressed or down, most of the day, nearly every day for the past two weeks; Depression(2) = participant reported having been much less interested in most things or much less able to enjoy the things that they used to enjoy most of the time over the past two weeks; Mania(1) = participant reported that they had a period of time when they felt 'up' or 'high' or 'hyper' or so 'full of energy', or 'full of themself' that they got into trouble, or that other people said that they were not their usual self; Mania(2) = Participant reported that they had been persistently irritable for several days, to the point that they had arguments or verbal or physical fights, or shouted at people outside their family, or had others notice that they over reacted to situations or been more irritable than usual compared to others–even when the participant thought their reaction was justified.

Prior to being entered into the study, 12% of participants rated their physical fitness level as being "very poor", 21% rated it as "poor", 42% as "average", and 15% as "good". No participants rated their fitness level as being "very good". Most participants (58%) reported that they "had been active in the past but were not currently active"; 27% reported being "active now and in the past", and 6% reported "never being active". When asked about physical activity over a seven day period, participants reported engaging in physical activity "sufficiently prolonged and intense enough to cause sweating and a rapid heartbeat" at least three times a week (9%), once or twice a week (39%), and rarely or never (46%). When asked about stage of change, 15% stated that they had "never been active in the past but were thinking about becoming more active"; 49% stated that they were "physically active once in a while, but not regularly"; 12% stated that they were "physically active, but have only just begun doing so"; and 18% stated that they "participate in regular activity and have done so for more than six months". No participants stated that they were "not planning on becoming active in the next six months". Participants were highly motivated to participate in the current study, reporting an average rating of 9.3 out of 11 (1 being *no motivation what–so–ever* and 11 being *extremely motivated*).

Table 1 summarizes the trauma history in the current sample. The most prevalent index traumas were experiencing a sudden and unexpected death of a loved one (18%; this trauma did not include death from natural causes), serious life threatening illness (15%), and serious motor vehicle accident (12%). Participants reported having experienced their index trauma anywhere from 0 to 37 years prior to completing the online screen (M = 8.4 years, SD = 11.4 years). The majority of participants reported their

index trauma occurring less than four years prior to entering into the study (61%); 13% reported that their index trauma occurred between one and 12 months prior to entering the study; 29% reported having experienced their index trauma over 10 years before entering the study.

Table 1. Indexed and referenced traumas

Traumatic event description	Index *n* (%)	Endorsed *n* (%)
Natural disaster (e.g., hurricane, earthquake)	0(0)	12(39)
Motor vehicle accident for which you received medical attention or that someone was badly injured or killed	4(12)	15(48)
Any other kind of accident where someone was badly hurt or killed	0(0)	8(26)
Combat or warfare	2(6)	2(6)
Sudden and unexpected death of a friend or loved one	6(18)	27(87)
Life threatening or disabling event to a loved one	1(3)	20(65)
Life threatening or disabling event to yourself	0(0)	11(35)
Robbery where a weapon was or was thought to be present	0(0)	9(29)
Assault by acquaintance	1(3)	11(35)
Assaulted by a stranger	1(3)	12(39)
Witnessed a severe assault to an acquaintance	0(0)	12(39)
Witnessed a severe assault to a stranger	0(0)	11(35)
Threatened by someone else with death or serious harm	0(0)	15(48)
Witnessed family violence while growing up	0(0)	14(45)
Severely physically punished while growing up	0(0)	19(61)
Physically hurt by an intimate partner	3(9)	14(45)
Before age 13: having sexual contact by someone 5 or more years older	2(6)	8(26)
Before age 13: experiencing unwanted sexual contact	0(0)	8(26)
As a teen: unwanted sexual contact	1(3)	10(32)
As an adult: unwanted sexual contact	0(0)	10(32)
Sexual harassment	0(0)	14(45)
Stalked	0(0)	9(29)
You or your romantic partner having a miscarriage	1(3)	11(35)
You or your romantic partner having an abortion	1(3)	12(39)
Learning or repeatedly being exposed to details of a distressing event	2(6)	26(84)
Some other traumatic event	0(0)	21(68)

Note: Index trauma refers to the event in which participants rated as being the most traumatizing that they had ever experienced; indexed traumas were used as an anchor for all PCL–C questions in the current study. Endorsed trauma refers to an event that a participant reported experiencing; however, it was not rated as being the most traumatic event they had ever encountered. Two participants chose not to endorse additional traumas beyond that which they considered their index event.

3.3 Preliminary Analyses

3.3.1 Assessing for differences in baseline variables between study groups. A one–way between–groups ANOVA was conducted to explore potential group differences in baseline variables between the three study groups. Result indicated that there were no significant differences in PCL–C total scores ($F[2,30] = .80$, $p = .46$), PCL–C re–experiencing ($F[2, 30] = 1.43$, $p = .26$), PCL–C avoidance ($F[2, 30] = .61$, $p = .55$), PCL–C numbing ($F[2, 30] = .12$, $p = .90$), PCL–C hyperarousal ($F[2, 30] = .63$, $p = .54$), ASI–3 total ($F[2, 30] = 1.70$, $p = .20$), ASI–3 physical ($F[2, 30] = 1.34$, $p = .28$), ASI–3 cognitive ($F[2, 30] = .89$, $p = .42$), ASI–3 social ($F[2, 30] = 2.70$, $p = .08$), CES–D total ($F[2, 30] = .04$, $p = .96$), motivation to participate ($F[2, 30] = 1.91$, $p = .46$), or estimated VO2 max scores ($F[2, 29] = 2.97$, $p = .21$). Table 2 summarizes the group means of each variable.

Table 2: Group means for study variables

		Online screen questionnaire means											Physical fitness testing	
		PCL–C total	PCL–C rxp	PCL–C avd	PCL–C nmb	PCL–C hyp	ASI–3 total	ASI–3 phy	ASI–3 cog	ASI–3 soc	CES–D	Motiv	Est. VO_{2max}	Health benefit zone
CD	*M*	58.36	17.27	6.82	13.36	20.90	44.27	13.18	14.91	16.18	52.45	9.36	328.10	4.18
	(*SD*)	(11.41)	(3.85)	(1.17)	(4.13)	(5.50)	(17.98)	(6.90)	(7.13)	(6.15)	(11.78)	(1.29)	(59.09)	(1.08)
EO	*M*	51.45	14.36	5.82	13.45	18.27	33.27	10.45	11.45	11.36	51.00	9.64	280.86	4.55
	(*SD*)	(13.60)	(4.74)	(2.27)	(4.18)	(6.07)	(15.58)	(7.02)	(6.17)	(5.22)	(11.27)	(1.75)	(66.74)	(.52)
IP	*M*	55.18	15.27	6.36	14.09	19.81	36.55	8.55	12.91	15.09	51.82	8.82	351.91	3.70
	(*SD*)	(13.32)	(3.74)	(2.66)	(3.65)	(5.08)	(7.38)	(6.04)	(4.81)	(3.59)	(13.89)	(1.60)	(78.81)	(1.42)

Note: CD = Cognitive distraction group; EO = exercise only group; IP = interoceptive prompts group; *M* = Mean; *SD* = Standard Deviation; PCL–C = Posttraumatic stress disorder checklist – civilian version; total = total scores; rxp = re–experiencing subscale; avd = avoidance subscale; nmb = numbing subscale; hyp = hyperarousal subscale; ASI–3 = Anxiety sensitivity Index 3; phy = physical fears subscale; cog = cognitive fears subscale; soc = socially observable fears subscale; CES–D = Center for epidemiological studies depression scale; Motiv = motivation to enter study; Est. = estimated.

3.3.2 Assessing for differences in baseline variables between completers and drop–outs.

An independent–samples *t*–test was conducted to assess for potential differences in study variables between completers (n = 27) and drop–outs (n = 6). There were no significant differences in scores among PCL–C total (t[31] = 1.40, p = .17), PCL–C re–experiencing (t[31] = .73, p = .47), PCL–C avoidance (t[31] = 2.02, p = .05), PCL–C numbing (t[31] = 1.78, p = 09), PCL–C hyperarousal (t[31] = .82, p = .42), ASI–3 total (t[31] = .28, p = .78), ASI–3 physical (t[31] = –.78, p = .44), ASI–3 cognitive (t[31] = .85, p = .40), ASI–3 social (t[31] = .78, p = .44), CES–D (t[31] = .39, p = .70), motivation (t[31] = .76, p = .45), or estimated VO2max (t[31] = 1.30, p = .20). Table 3 summarizes the means of each variable for completers and drop–outs.

Table 3. Study variable means among completers and drop–outs.

		Online screen questionnaire means											Physical fitness testing	
		PCL–C total	PCL–Crxp	PCL–Cavd	PCL–Cnmb	PCL–Chyp	ASI–3 total	ASI–3 phy	ASI–3 cog	ASI–3 soc	CES–D	Motiv	Est. VO2max	Health benefit zone
Completers	*M*	56.44	15.89	6.67	14.19	20.04	38.37	10.30	13.52	14.56	52.15	9.37	327.24	4.12
	(*SD*)	(12.39)	(3.95)	(1.97)	(3.97)	(5.41)	(15.60)	(6.86)	(5.97)	(5.75)	(12.39)	(1.60)	(68.61)	(1.14)
Drop–outs	*M*	48.50	14.50	4.83	11.17	18.00	36.50	12.67	11.17	12.67	50.00	8.83	284.90	4.33
	(*SD*)	(13.34)	(5.43)	(2.31)	(2.31)	(6.10)	(10.58)	(6.34)	(6.82)	(2.94)	(10.83)	(1.33)	(85.63)	(.82)

Note: *M* = Mean; *SD* = Standard deviation; PCL–C = Posttraumatic stress disorder checklist – civilian version; total = total scores; rxp = re–experiencing subscale; avd = avoidance subscale; nmb = numbing subscale; hyp = hyperarousal subscale; ASI–3 = Anxiety sensitivity Index 3; phy = physical fears subscale; cog = cognitive fears subscale; soc = socially observable fears subscale; CES–D = Center for epidemiological studies depression scale; Est. = estimated; Motiv = Motivation to enter study.

3.3.3 Assessing for differences between the online screen and pre–treatment data collection points. To assess for potential differences in the online screen and pre–treatment scores, a paired–samples *t*–test was performed on each of the study variables. Results indicated PCL–C hyperarousal ($t[32] = 4.63$, $p = .013$) and PCL–C re–experiencing ($t[32] = 2.12$, $p = .04$) were significant at the $p < .05$ level; however, the difference failed to meet the established minimum cut–off for significance (i.e., $p < .01$) in the current study. No other significant differences were observed. Due to the overall lack of significant differences study variable scores at the online screen and pre–treatment stage, the decision was made to use the pre–treatment data collection point as the first data point in subsequent analyses. Study variable mean scores obtained from the online screen and pre–treatment time points are summarized in Table 4.

Table 4: Mean study variables at online screen and pre–treatment time points

	Online screen		Pre–treatment	
	Mean	Standard deviation	Mean	Standard deviation
PCL–C rxp	15.64	4.19	14.18	3.84
PCL–C avd	6.33	2.10	6.55	2.73
PCL–C nmb	13.64	3.88	14.52	4.80
PCL–C hyp	19.67	5.50	17.20	4.92
PCL–C tot	55.00	12.73	51.32	12.93
ASI–3 tot	38.03	14.69	38.33	12.71
ASI–3 cog	13.10	6.09	13.18	5.54
ASI–3 phy	10.73	6.74	10.36	6.31
ASI–3 soc	14.21	5.36	14.79	5.22
CES–D tot	51.76	11.99	51.52	11.65
Motivation	9.28	1.55	10.15	1.25

PCL–C = Posttraumatic stress disorder checklist – civilian version; total = total scores; rxp = re–experiencing subscale; avd = avoidance subscale; nmb = numbing subscale; hyp = hyperarousal subscale; ASI–3 = Anxiety sensitivity Index 3; phy = physical fears subscale; cog = cognitive fears subscale; soc = socially observable fears subscale; CES–D = Center for epidemiological studies depression scale; Motivation = motivation to enter study.

3.3.4 Assessing for differences in exercise response questions between groups.

Means for each of the exercise response questions are graphically represented in Figures 4 through 7; as well, means of each exercise response question are presented in Table 5. The predicted means for motivation after session 6 were 10.55, 8.55, and 10.00 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. In general, motivation ratings rose in a quadratic fashion ($p = .017$); however, the rate of increase was not sufficient enough to surpass the cut–point for statistical significance in the current study (i.e., $p < .01$). Likewise, the linear variable ($p = .026$) and main effect of group membership ($p = .032$) did not surpass the significance cut–point for the current study. The interaction between group and time ($p = .001$) was statistically significant. Results showed that no other between group differences in terms of intercepts were found. In terms of slope of motivation ratings, results showed that the interoceptive prompts group was significantly less pronounced than the exercise only group ($t[160.32] = –3.35$, $p = .001$); no other between group differences in slope were found.

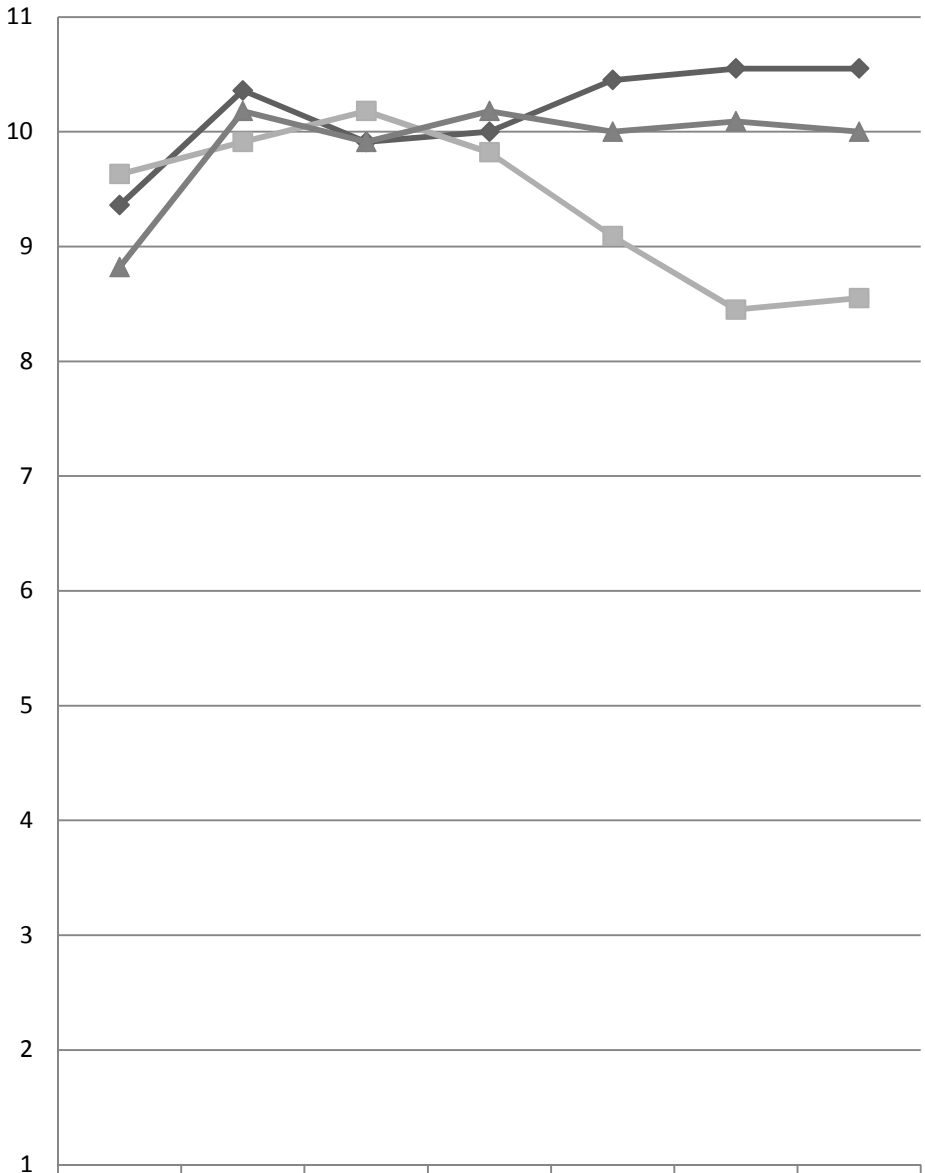
The predicted means for difficulty ratings after session 6 were 5.82, 6.82, and 6.27 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. Results showed no significant change in difficulty ratings in either a linear ($p = .174$) or quadratic ($p = .172$) fashion. The main effect of group ($p = .278$) and the interaction of group and time ($p = .086$) were not statistically significant.

The predicted means for physical attention ratings after session 6 were 6.00, 7.27, and 7.09 for the cognitive distraction, exercise only, and interoceptive prompts respectively. The ratings of attention paid to physical sensations brought on by the exercise conducted did not change significantly in a linear ($p = .246$) or quadratic ($p =$

.257).fashion. The main effect of group membership was not statistically significant (p = .225), nor was the interaction between group and time (p = .984).

The predicted means for enjoyment ratings after session 6 were 9.00, 8.00, and 8.64 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. Enjoyment ratings did not change in either a linear (p = .469) or fashion (p = .496) quadratic during the course of the study. The main effect of group membership (p = .294) and the interaction between group and time (p = .223) were not statistically significant.

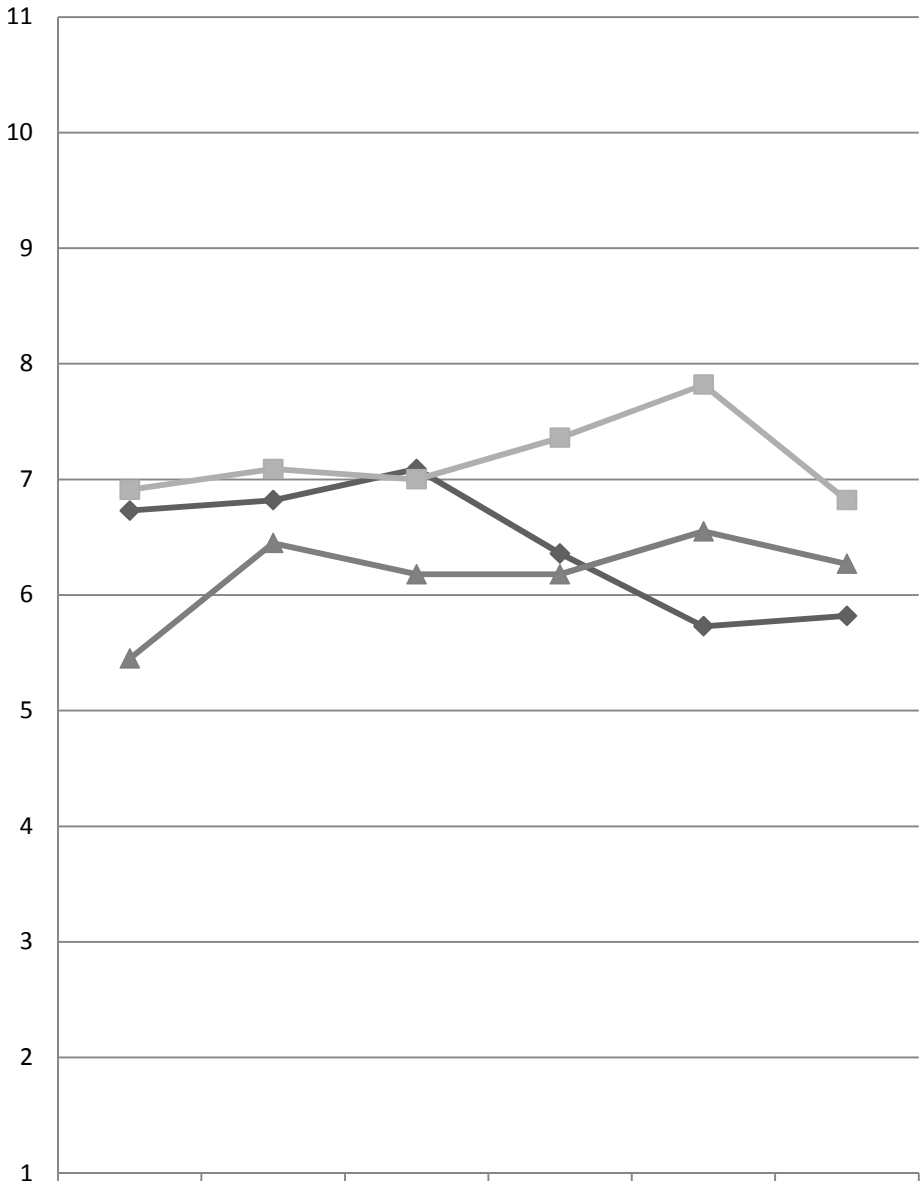
Figure 4: Mean motivation ratings (Multiply imputed using the predictive mean matching method)



	1	2	3	4	5	6	7
cognitive distraction	9.36	10.36	9.91	10	10.45	10.55	10.55
exercise only	9.63	9.91	10.18	9.82	9.09	8.45	8.55
interoceptive prompts	8.82	10.18	9.91	10.18	10	10.09	10

Note: X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6); Y–axis depicts study group motivation; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

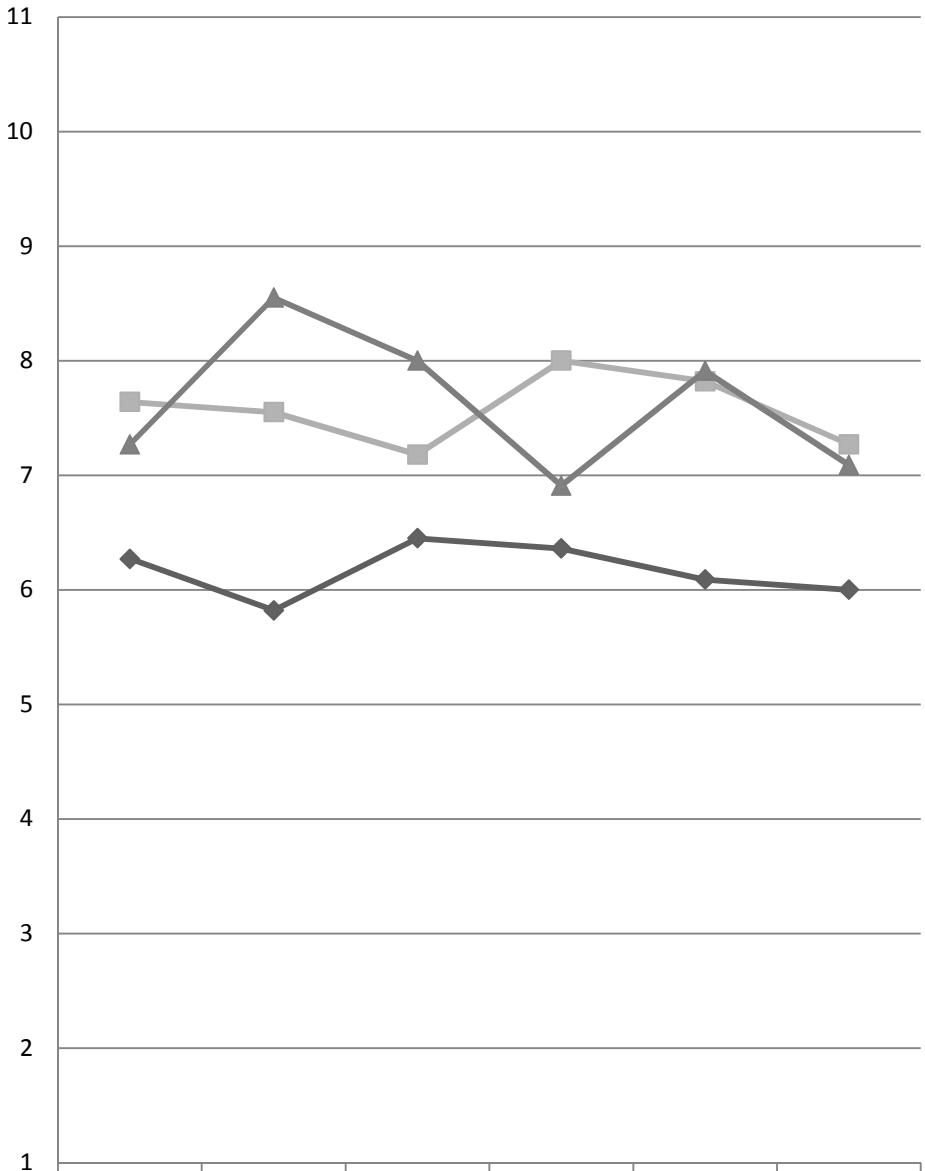
Figure 5: Mean difficulty ratings (Multiply imputed using the predictive mean matching method)



	1	2	3	4	5	6
cognitive distraction	6.73	6.82	7.09	6.36	5.73	5.82
exercise only	6.91	7.09	7	7.36	7.82	6.82
interoceptive prompts	5.45	6.45	6.18	6.18	6.55	6.27

Note: X axis depicts assessment point (1 = session 1, 2 = session 2, 3 = session 3, 4 = session 4, 5 = session 5, 6 = session 6); Y–axis depicts study group difficulty ratings; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

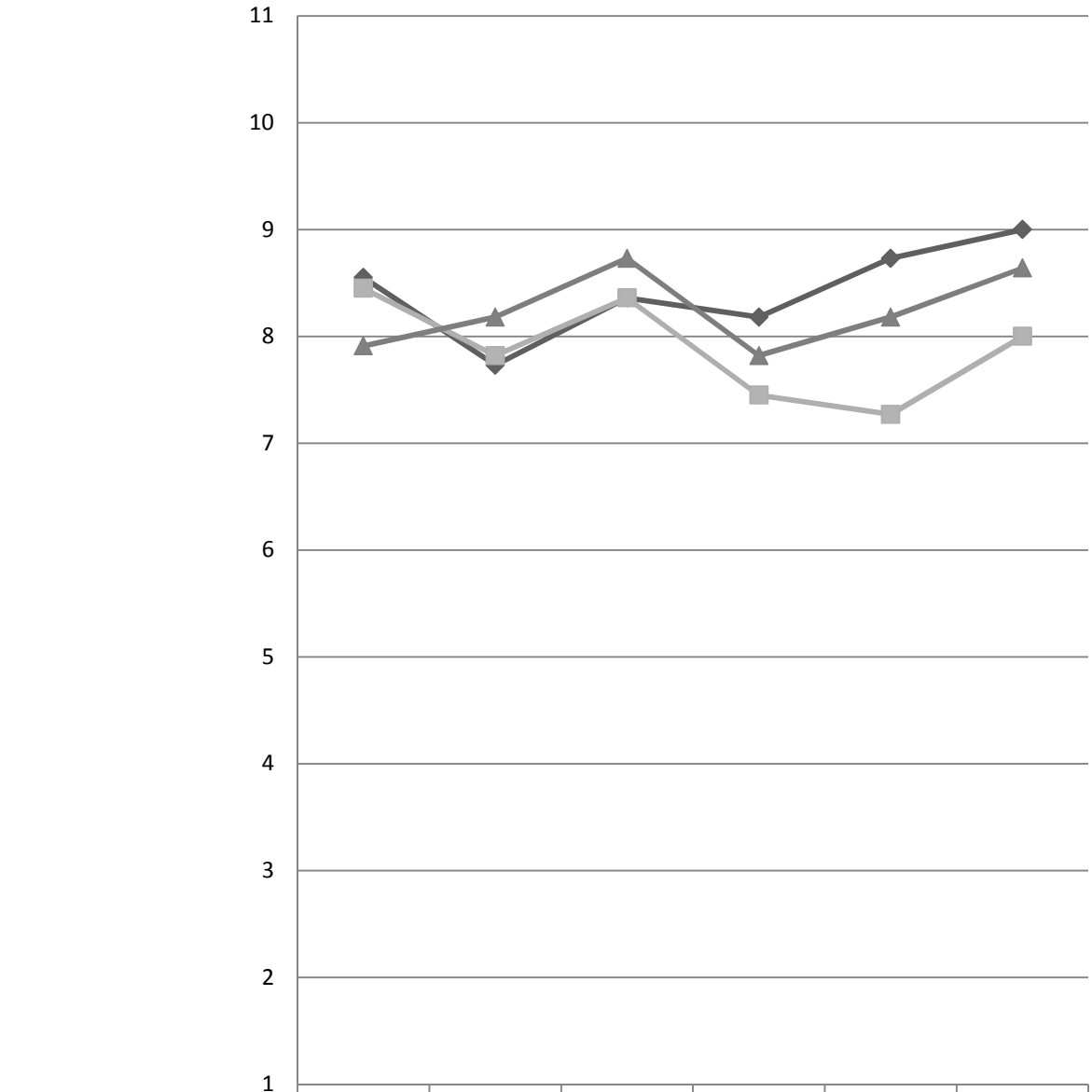
Figure 6: Mean physical attention ratings (Multiply imputed using the predictive mean matching method)



	1	2	3	4	5	6
cognitive distraction	6.27	5.82	6.45	6.36	6.09	6
exercise only	7.64	7.55	7.18	8	7.82	7.27
interoceptive prompts	7.27	8.55	8	6.91	7.91	7.09

Note: X axis depicts assessment point (1 = session 1, 2 = session 2, 3 = session 3, 4 = session 4, 5 = session 5, 6 = session 6); Y–axis depicts study group physical attention ratings; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

Figure 7: Mean enjoyment ratings (Multiply imputed using the predictive mean matching method)



	1	2	3	4	5	6
cognitive distraction	8.55	7.73	8.36	8.18	8.73	9
exercise only	8.45	7.82	8.36	7.45	7.27	8
interoceptive prompts	7.91	8.18	8.73	7.82	8.18	8.64

Note: X axis depicts assessment point (1 = session 1, 2 = session 2, 3 = session 3, 4 = session 4, 5 = session 5, 6 = session 6); Y–axis depicts study group enjoyment ratings; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

Table 5: Mean exercise response questions scores by study group.

	Motivation			Difficulty			Physical attention			Enjoyment		
	CD	EO	IP	CD	EO	IP	CD	EO	IP	CD	EO	IP
Pre–treatment	9.36	9.63	8.82	—	—	—	—	—	—	—	—	—
Session 1	10.36	9.91	10.18	6.73	6.91	5.45	6.27	7.64	7.27	8.55	8.45	7.91
Session 2	9.91	10.18	9.91	6.82	7.09	6.45	5.82	7.55	8.55	7.73	7.82	8.18
Session 3	10.00	9.82	10.18	7.09	7.00	6.18	6.45	7.18	8.00	8.36	8.36	8.73
Session 4	10.45	9.09	10.00	6.36	7.36	6.18	6.36	8.00	6.91	8.18	7.45	7.82
Session 5	10.55	8.45	10.09	5.73	7.82	6.55	6.09	7.82	7.91	8.73	7.27	8.18
Session 6	10.55	8.55	10.00	5.82	6.82	6.27	6.00	7.27	7.09	9.00	8.00	8.64

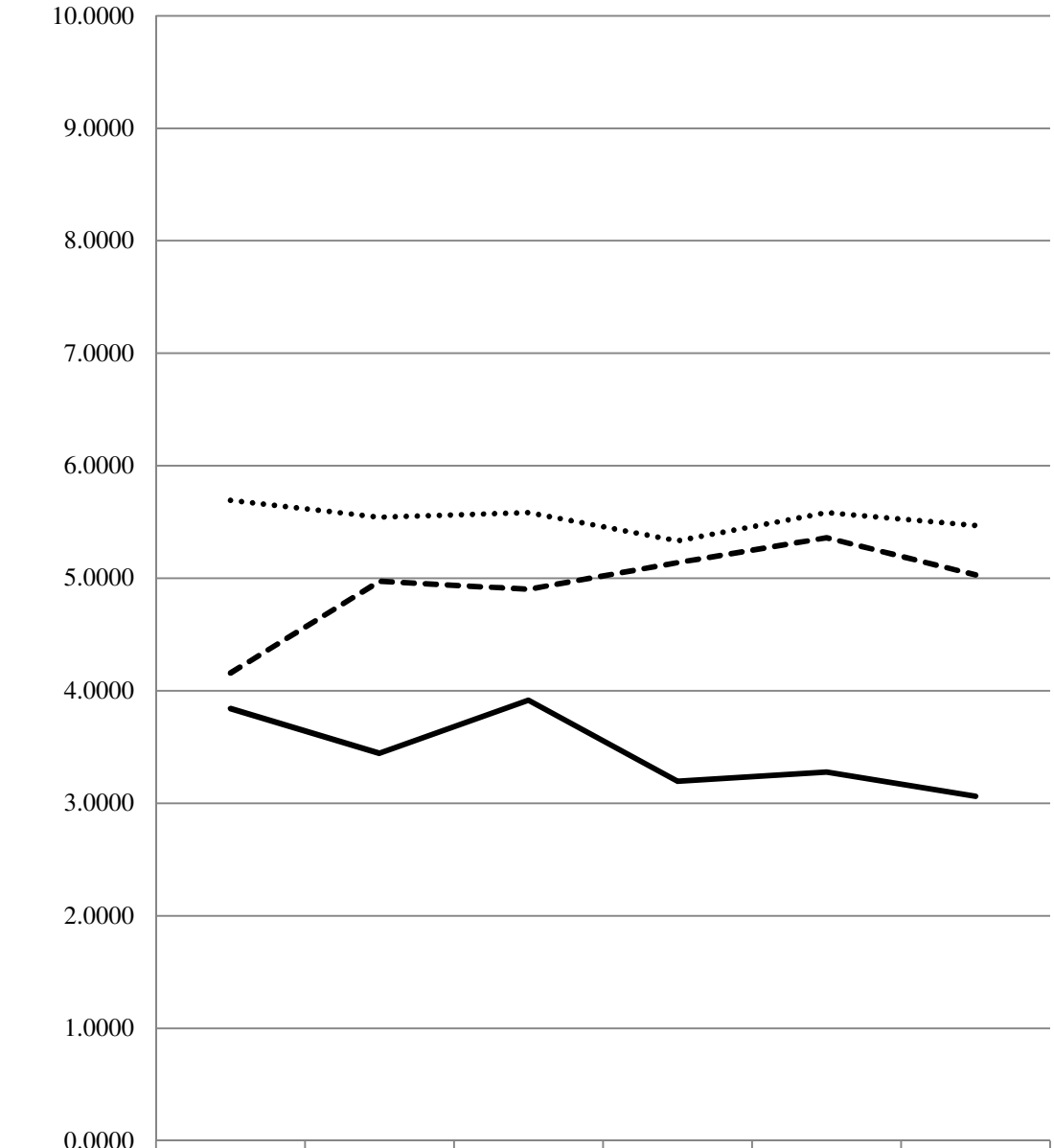
Note: CD = cognitive distraction group; EO = Exercise only group; IP = Interoceptive prompts group; Motivation = How motivated are you to continue with the current study/continue exercising?; Difficulty = How difficult did you find the exercise session today?; Trauma memories = How much did the exercise session today elicit memories of the trauma you had experienced?; Physical attention = How much did you pay attention to the physical sensations brought on by the exercise you conducted today?; Enjoyment = How much did you enjoy . Only motivation ratings were taken at pre-treatment.

3.3.5 Treatment manipulation fidelity

3.3.5.1 Cognitive distraction task. Participants in the cognitive distraction group were asked a total of 12 questions over the course of each 20 minute exercise session. Participants answered an average of 9 (*SD* = 1.67; 75%) questions correctly each session. Average scores across each of the six exercise sessions ranged from 5.5 to 11.

3.3.5.2 Interoceptive prompts. Three paired samples t–tests were performed to assess for significant changes between mean interoceptive prompt ratings given in session 1 and 6. Results indicated that interoceptive prompts targeting muscles in participant's legs ($t[7] = .35$, $p = .74$), upper body ($t[7] = 1.87$, $p = .10$), or breathing ($t[7] = –2.02$, $p = .08$) did not change significantly over the course of the six sessions. A noticeable but non–significant trend in the three mean interoceptive prompt ratings was that the leg and upper body muscle focused prompts appeared to decrease over the six sessions, whereas the prompt focusing on the participant breathing appeared to increase over the six sessions. Figure 8 illustrates the mean leg, upper body, and breathing interoceptive prompt ratings for the interoceptive prompts group.

Figure 8: Mean interoceptive prompts ratings



	1	2	3	4	5	6
leg	5.6936	5.5422	5.5833	5.3333	5.5833	5.4688
upper	3.8409	3.4444	3.9167	3.1944	3.2778	3.0625
breath	4.1591	4.9722	4.9033	5.1389	5.3611	5.0313

Note: Numerical values in table represent mean interoceptive prompts ratings by group; X axis = session number.

3.4 Primary statistical analyses.

The level 1 portion of the HLM model (the part estimating outcomes as a function of time within individuals) was $\text{Outcome}_{ij} = b_{0i} + b_{1i} \times \text{Time}_{ij} + \varepsilon_{ij}$, where i represents each individual subject and j represents the nine assessment points (pre–treatment, session 1, session 2, session 3, session 4, session 5, session 6, week follow–up, and month follow–up). Assessment points were coded, in chronological order (i.e., –6, –5, –4, –3, –2, –1, 0, 1, 2) for each of the primary outcome variables in order to compare intercepts between study groups after the treatment phase (i.e., after session 6); thus b_{0i} represents the outcome for individual i at assessment point 0 (session 6), b_{1i} represents the slope of change in outcome for subject i across assessment points, and ε_{ij} represents the error in predicting outcome j for individual i (random variation). The level 2 portion of the model allowed for differences among individuals in the intercept and slope (from level 1 model) to be determined by experimental group (i.e., cognitive distraction, exercise only, and interoceptive prompts). Group membership was coded using dummy variables in order to facilitate comparisons between group intercepts and slopes of change among primary outcome variables. Because of the possibility that the rate of change across assessment points might be nonlinear, the original level 1 model included an additional term to allow for a curvilinear treatment effect. The same time–centering coding procedure was used for both the linear and quadratic terms. This additional term allowed for the assessment the speed of change (i.e., whether or not participant's measures scores rate of change slowed or advanced as time passed) in addition to the trend of change provided by the linear term (i.e., whether or not participant's measure scores changed as time passed).

3.4.1 PCL–C total scores. The multiply imputed means for each primary outcome variable for each study group are independently presented in figures 7 through 17. For comparative purposes, these means are also presented in Tables 8 through 16 along with three alternative methods of missing data strategies (i.e., mahalanobis matching method [multiple imputation], last observation carried forward [single imputation], and completers only). The predicted means for PCL–C total scores after session 6 were 37.55, 33.80, and 35.63 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. PCL–C total scores showed statistically significant declines over the course of the study in a quadratic fashion ($p < .001$); the linear trend was also found to be statistically significant ($p = .005$). The interaction between group and time was not statistically significant ($p = .589$). The main effect of group was not statistically significant ($p = .685$). The effect sizes for the reduction in PCL–C total scores during treatment portion of the study for the cognitive distraction ($d = 1.18$), exercise only ($d = .98$), and interoceptive prompts ($d = 1.25$) groups were all large.

Results suggest that PCL–C total scores reduced in a fashion consistent with an expedited trajectory during the in–lab phase of the study. The trajectory of PCL–C total scores changed during the follow–up phases wherein scores began to rise. Findings also indicated no interaction between time and group, and that group membership was not a significant factor in PCL–C scores, which would suggest that group membership did not have an impact on the trajectory of PCL–C total scores.

HLM with alternative methods of missing data imputation (mahalanobis matching method, last observation carried forward, and completers only) each suggested that there

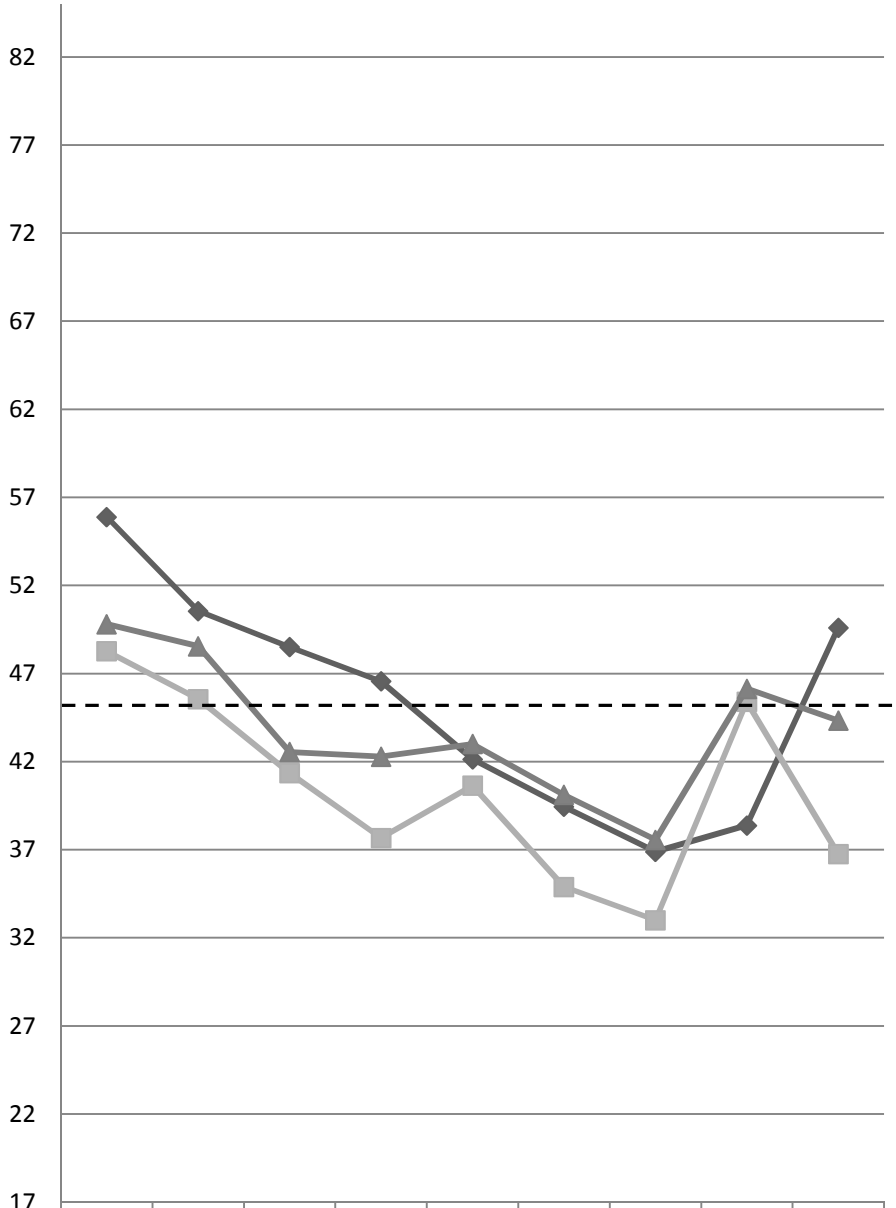
were no effects of group membership (all p's > .171). Interactions between group and time were only found to be significant using the mahalonobis method ($p < .001$). More specifically, these results suggested that although there were no differences in slope intercepts, the interoceptive prompts group demonstrated a significantly less pronounced slope of decline in PCL–C total scores ($p < .001$). Each method suggested that PCL–C total scores decreased in a quadratic function (all p's < .001), rather than a linear fashion (all p's > .613). Main effects of group membership was not found to be significant with each method (all p's > .128). As such, results from alternative methods of data imputation are largely consistent with the predictive mean matching method.

Table 6: PCL–C total score means from various imputation methods.

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Pre treatment	55.89	—	—	—	48.27	—	—	—	49.80	—	—	—
Session 1	50.55	—	—	—	45.55	—	—	—	48.55	—	—	—
Session 2	48.50	46.55	48.27	46.36	41.35	40.05	41.23	39.59	42.55	42.55	46.36	44.68
Session 3	46.56	45.45	45.64	45.73	37.67	36.59	36.68	37.73	42.28	41.86	45.32	43.18
Session 4	42.14	41.84	40.84	42.11	40.64	40.16	40.57	40.25	43.00	41.64	45.73	43.77
Session 5	39.44	39.82	36.73	39.82	34.89	36.69	34.58	35.45	40.11	37.73	43.91	41.41
Session 6	36.89	37.55	34.82	37.64	33.00	33.80	33.27	31.70	37.56	35.64	41.82	39.31
Week follow–up	38.38	42.73	37.27	40.55	45.40	40.86	37.59	36.91	46.13	44.27	48.27	46.35
Month follow–up	49.60	48.00	43.82	45.36	36.75	38.91	36.91	38.73	44.33	47.00	52.36	44.75

Note: pretreatment and session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

Figure 7: PCL–C total score multiply imputed means for total sample and experimental groups.



	1	2	3	4	5	6	7	8	9
cognitive distraction	55.89	50.55	48.5	46.56	42.14	39.44	36.89	38.38	49.6
exercise only	48.27	45.55	41.35	37.67	40.64	34.89	33	45.4	36.75
interoceptive prompts	49.8	48.55	42.55	42.28	43	40.11	37.56	46.13	44.33

Note: Horizontal dotted line denotes cut–score for PCL–C indicating likely posttraumatic stress disorder (National Center for PTSD, 2010); X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6, 8 = week follow–up, 9 = month follow–up; Y–axis depicts study group PCL–C

total score; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

3.4.2 PCL–C re–experiencing scores. The predicted means for PCL–C re–experiencing subscale scores after session 6 were 9.09, 9.54, and 9.09 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. PCL–C re–experiencing scores showed statistically significant declines over the course of the study in a quadratic fashion ($p < .001$), whereas the linear variable was not found to be statistically significant ($p = .572$). The interaction between group and time was not statistically significant ($p = .420$). The main effect of group membership on PCL–C re–experiencing scores was not statistically significant ($p = .572$). The effect size for the change in PCL–C re–experiencing scores during the treatment portion of the study for the cognitive distraction ($d = 1.73$), exercise only ($d = .73$), and interoceptive prompts ($d = .91$) groups were large, medium, and large respectively.

Results suggest that PCL–C re–experiencing subscale scores reduced significantly, with an expedited trajectory during the in–lab phase of the study; however, scores increased during the follow–up phases. Findings also indicated no interaction between time and group, and no significant effect of group membership, which would suggest that group membership did not have an impact on the trajectory of PCL–C re–experiencing scores.

HLM with alternative methods of missing data imputation (mahalanobis matching method, last observation carried forward, and completers only) each suggested that there was no main effects of group membership (all p's > .422) and no group and time interaction (all p's > .165), and that PCL–C re–experiencing score reduced in a quadratic fashion (all p's < .001). Only last observation carried forward method suggested that PCL–C re–experiencing score reduced in a linear trend ($p = .037$) in addition to the

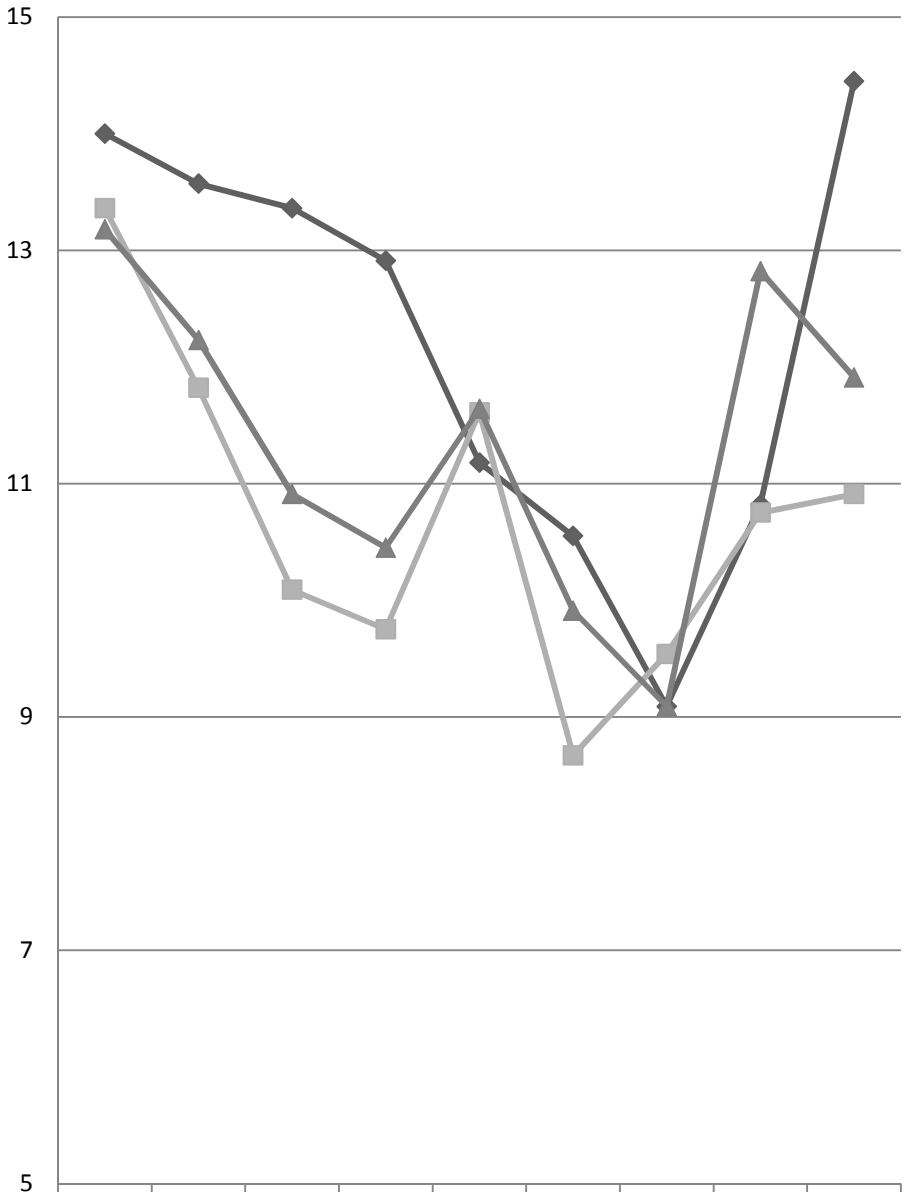
quadratic trend; however, this did not surpass the established $p < .01$ cut–point for the current study. As such, results from alternative methods of data imputation are largely consistent with the predictive mean matching method.

Table 7: PCL–C re–experiencing subscale score means from various imputation methods.

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Pre treatment	14.00	—	—	—	13.36	—	—	—	13.18	—	—	—
Session 1	13.57	—	—	—	11.82	—	—	—	12.23	—	—	—
Session 2	13.80	13.36	13.09	13.09	10.50	10.09	10.36	10.09	11.11	10.91	10.82	11.18
Session 3	12.78	12.91	12.45	12.81	10.11	9.75	9.99	10.00	11.00	10.45	12.36	11.09
Session 4	11.78	11.18	11.27	12.00	11.22	11.61	11.44	10.91	11.89	11.64	12.45	11.81
Session 5	10.89	10.55	10.36	11.27	8.33	8.67	8.70	8.55	10.22	9.91	10.36	10.45
Session 6	9.67	9.09	9.27	10.27	9.00	9.54	8.92	9.09	9.11	9.09	9.27	9.55
Week follow–up	11.13	10.82	11.36	12.09	12.60	10.75	11.50	10.27	12.50	12.82	11.55	11.82
Month follow–up	14.60	14.45	13.73	14.00	11.25	10.91	11.09	10.82	11.50	11.91	11.00	11.09

Note: pretreatment and session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

Figure 8: PCL–C re–experiencing subscale score multiply imputed means for total sample and experimental groups.



	1	2	3	4	5	6	7	8	9
cognitive distraction	14	13.57	13.36	12.91	11.18	10.55	9.09	10.82	14.45
exercise only	13.36	11.82	10.09	9.75	11.61	8.67	9.54	10.75	10.91
interoceptive prompts	13.18	12.23	10.91	10.45	11.64	9.91	9.09	12.82	11.91

Note: X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6, 8 = week follow–up, 9 = month follow–up; Y–axis depicts study group PCL–C re–experiencing score; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

3.4.3 PCL–C avoidance scores. The predicted means for PCL–C avoidance subscale scores after session 6 were 4.45, 3.95, and 4.59 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. Results suggested that PCL–C avoidance scores declined significantly over the course of the study, indicated by the both the quadratic ($p < .001$) and linear ($p = .002$) terms being statistically significant. The interaction between group and time was not statistically significant ($p = .786$). The main effect of group membership on PCL–C avoidance scores was not statistically significant ($p = .753$). The effect sizes for the change in PCL–C avoidance scores during the treatment portion of the study for the cognitive distraction ($d = .92$), exercise only ($d = .77$), and interoceptive prompts ($d = .69$) groups were large, medium, and medium respectively.

Results suggest that PCL–C avoidance subscale scores reduced significantly in an expedited trajectory during the first three in–lab sessions; after which, decline in PCL–C avoidance scores appeared to decelerate in sessions 4, 5 and 6. During the follow–up phase, PCL–C avoidance scores in each group rose. Findings also indicated no interaction between time and group, and no effect of group, which would suggest that group membership did not have an impact on the trajectory of PCL–C avoidance scores.

HLM with alternative methods of missing data imputation (mahalanobis matching method, last observation carried forward, and completers only) each suggested that there were no main effects of group membership (all p's > .622) and group and time interaction (all p's > .355), and that PCL–C avoidance score reduced in a quadratic fashion (all p's < .01). Only last observation carried forward method suggested that PCL–C avoidance score reduced in a linear trend ($p = .038$) in addition to the quadratic trend; however, this

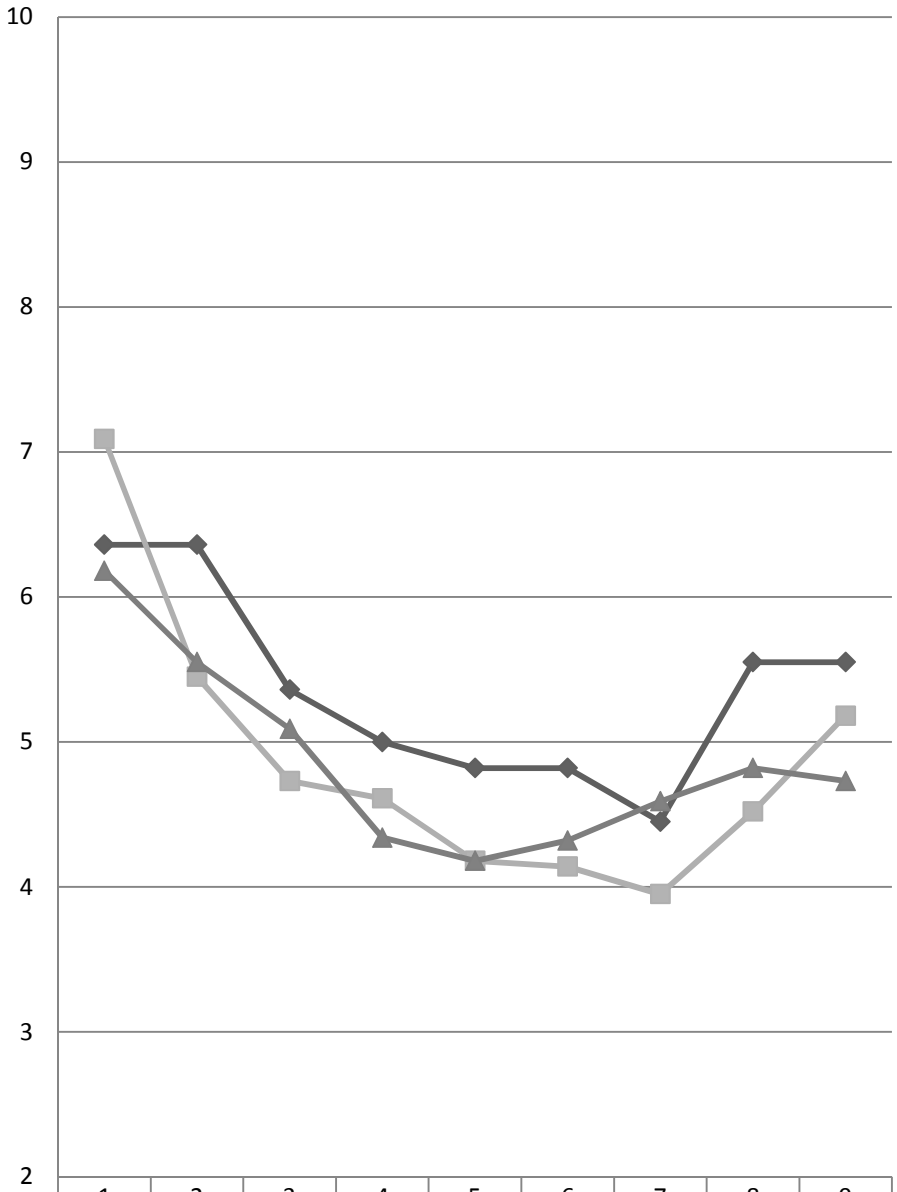
was not statistically significant at the established cut–point for the current study. As such, results from alternative methods of data imputation are largely consistent with the predictive mean matching method.

Table 8: PCL–C avoidance subscale score means from various imputation methods

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Pre treatment	6.36	—	—	—	7.09	—	—	—	6.18	—	—	—
Session 1	6.36	—	—	—	5.45	—	—	—	5.55	—	—	—
Session 2	5.60	5.36	5.45	5.36	4.80	4.73	4.73	4.55	5.33	5.09	5.18	5.36
Session 3	5.11	5.00	5.09	5.18	4.78	4.61	4.61	4.55	4.56	4.34	4.36	4.73
Session 4	4.67	4.82	4.18	4.81	4.33	4.18	4.18	4.18	4.22	4.18	3.91	4.45
Session 5	4.89	4.82	4.36	5.00	4.33	4.14	4.23	4.18	4.44	4.32	4.09	4.64
Session 6	4.56	4.45	4.09	4.73	4.00	3.95	3.95	3.91	4.67	4.59	4.27	4.82
Week follow–up	4.88	5.55	4.36	5.00	5.80	4.52	4.34	4.36	4.88	4.82	4.09	4.82
Month follow–up	5.60	5.55	5.36	5.36	5.50	5.18	4.36	4.82	4.67	4.73	4.82	4.91

Note: pretreatment and session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

Figure 9: PCL–C avoidance subscale score multiply imputed means for total sample and experimental groups.



	1	2	3	4	5	6	7	8	9
cognitive distraction	6.36	6.36	5.36	5	4.82	4.82	4.45	5.55	5.55
exercise only	7.09	5.45	4.73	4.61	4.18	4.14	3.95	4.52	5.18
interoceptive prompts	6.18	5.55	5.09	4.34	4.18	4.32	4.59	4.82	4.73

Note: X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6, 8 = week follow–up, 9 = month follow–up; Y–axis depicts study group PCL–C avoidance score; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

3.4.4 PCL–C numbing scores. The predicted means for PCL–C numbing subscale scores after session 6 were 10.27, 9.94, and 10.91 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. Results demonstrated that PCL–C numbing scores showed statistically significant declines over the course of the study in a quadratic fashion ($p < .001$); the linear term was not found to be statistically significant ($p = .743$). The interaction between group and time was not statistically significant ($p = .756$). The main effect of group membership on PCL–C numbing scores was not found to be statistically significant ($p = .802$). The effect sizes for the change in PCL–C numbing scores during the treatment portion of the study for the cognitive distraction ($d = 1.03$), exercise only ($d = 1.03$), and interoceptive prompts ($d = .69$) groups were large, large, and medium respectively.

Results suggest that PCL–C numbing subscale scores reduced significantly in an expedited trajectory during in–lab portion of the study. During the follow–up phase, however, PCL–C numbing scores in each group rose. Findings also indicated no interaction between time and group which would suggest that group membership did not have an impact on the trajectory of PCL–C numbing scores.

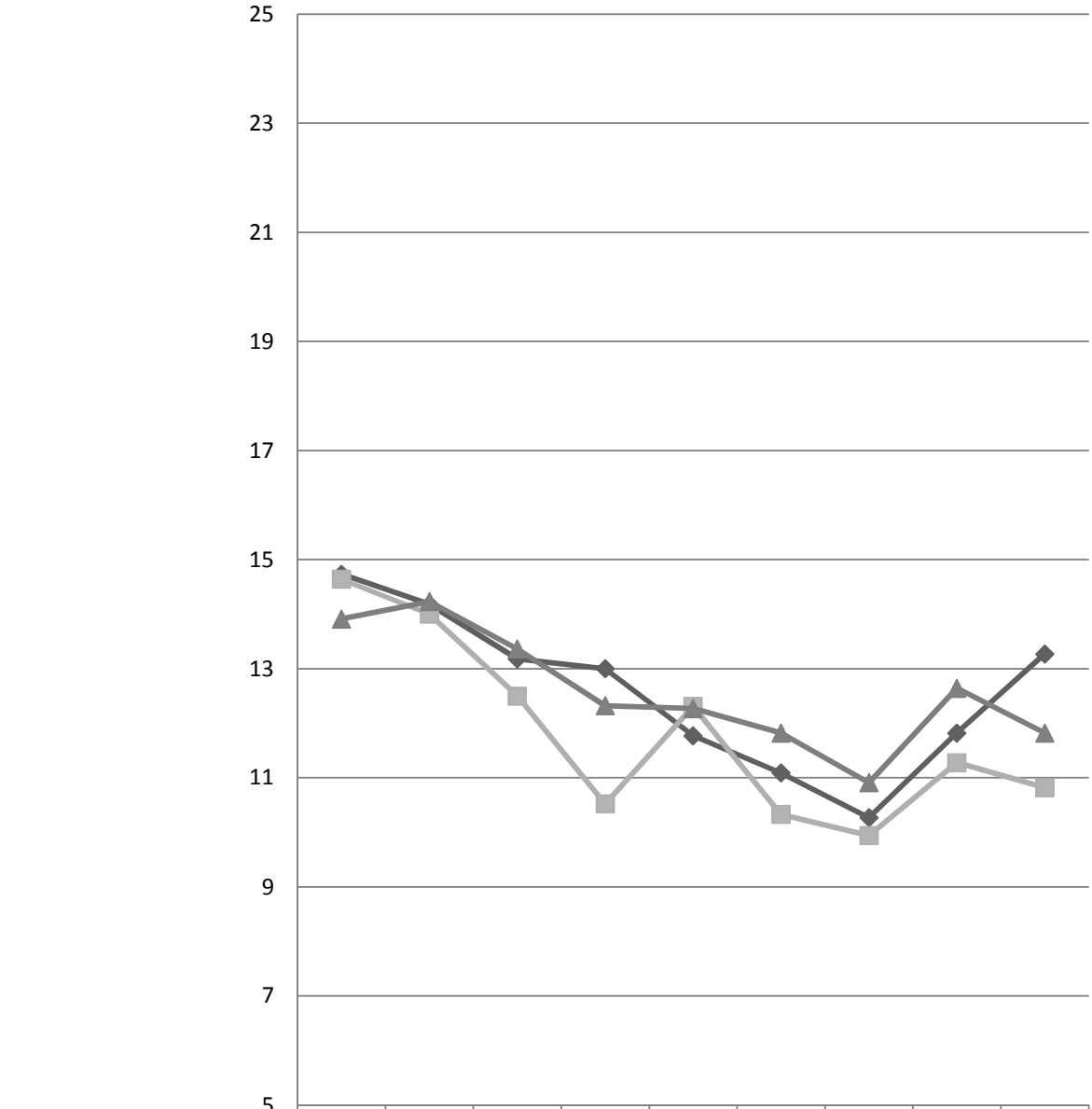
HLM with alternative methods of missing data imputation (Mahalanobis matching method, last observation carried forward, and completers only) suggested that PCL–C numbing scores reduced in a quadratic fashion (all p's $< .006$). The effect of time in a linear fashion with each imputation method was not statistically significant, nor was the main effect of group membership (all p's $> .622$), and group and session interaction (all p's $> .533$). As such, results from alternative methods of data imputation are largely consistent with the predictive mean matching method.

Table 9: PCL–C numbing subscale score means from various imputation methods

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Pre treatment	14.73	—	—	—	14.64	—	—	—	13.91	—	—	—
Session 1	14.18	—	—	—	14.00	—	—	—	14.23	—	—	—
Session 2	13.70	13.18	13.00	13.09	12.95	12.50	12.95	12.41	13.22	13.36	13.36	13.23
Session 3	13.78	13.00	13.45	13.09	10.67	10.52	12.01	11.18	12.06	12.32	12.14	12.27
Session 4	12.36	11.77	12.96	11.93	12.53	12.31	12.89	12.70	12.33	12.27	12.27	12.50
Session 5	11.33	11.09	11.27	11.09	11.11	10.33	12.46	11.55	12.22	11.82	12.18	12.41
Session 6	10.67	10.27	10.45	10.55	10.00	9.94	11.55	10.64	10.78	10.91	10.91	11.23
Week follow–up	11.25	11.82	11.27	11.55	13.40	11.28	11.99	10.82	12.88	12.64	12.45	12.59
Month follow–up	15.40	13.27	15.09	13.18	8.25	10.82	10.82	10.82	13.00	11.82	13.64	11.95

Note: pretreatment and session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

Figure 10: PCL–C numbing subscale score multiply imputed means for total sample and experimental groups.



	1	2	3	4	5	6	7	8	9
cognitive distraction	14.73	14.18	13.18	13	11.77	11.09	10.27	11.82	13.27
exercise only	14.64	14	12.5	10.52	12.31	10.33	9.94	11.28	10.82
interoceptive prompts	13.91	14.23	13.36	12.32	12.27	11.82	10.91	12.64	11.82

Note: X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6, 8 = week follow–up, 9 = month follow–up; Y–axis depicts study group PCL–C numbing score; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

3.4.5 PCL–C hyperarousal scores. The predicted means for PCL–C hyperarousal subscale scores after session 6 were 11.27, 10.00, and 12.27 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. Participants showed statistically significant improvements in PCL–C hyperarousal scores over the course of the study in a quadratic fashion ($p < .001$); the linear term was not found to be statistically significant ($p = .307$). The main effect of group membership was not statistically significant ($p = .427$).The interaction between group and time was statistically significant ($p = .024$) at the $p<.05$ level; however, not at the established significance cut–off for the current study. Notwithstanding, differences between study group slope and intercepts were examined, results indicated that there were no differences in intercepts between groups, but that the slope of the change in PCL–C hyperarousal scores was significantly less so among the interoceptive prompts group than the cognitive distraction group ($t[171.69]=2.76$, $p = .006$); differences between interoceptive prompts and exercise only ($p = .194$) and cognitive distraction and exercise only groups ($p = .148$) were not statistically significant. The effect sizes for the change in PCL–C hyperarousal scores during the treatment portion of the study for the cognitive distraction ($d = 1.54$), exercise only ($d = 1.37$), and interoceptive prompts ($d = 1.32$) groups were all large.

Results suggest that PCL–C hyperarousal subscale scores reduced significantly in an expedited trajectory during in–lab portion of the study. During the follow–up phase, however, PCL–C numbing scores in each group rose. Findings also indicated although each group did not differ in their outcome PCL–C numbing scores, the trajectory of the

decline from pre–treatment was less among the interoceptive prompts group than in the cognitive distraction group.

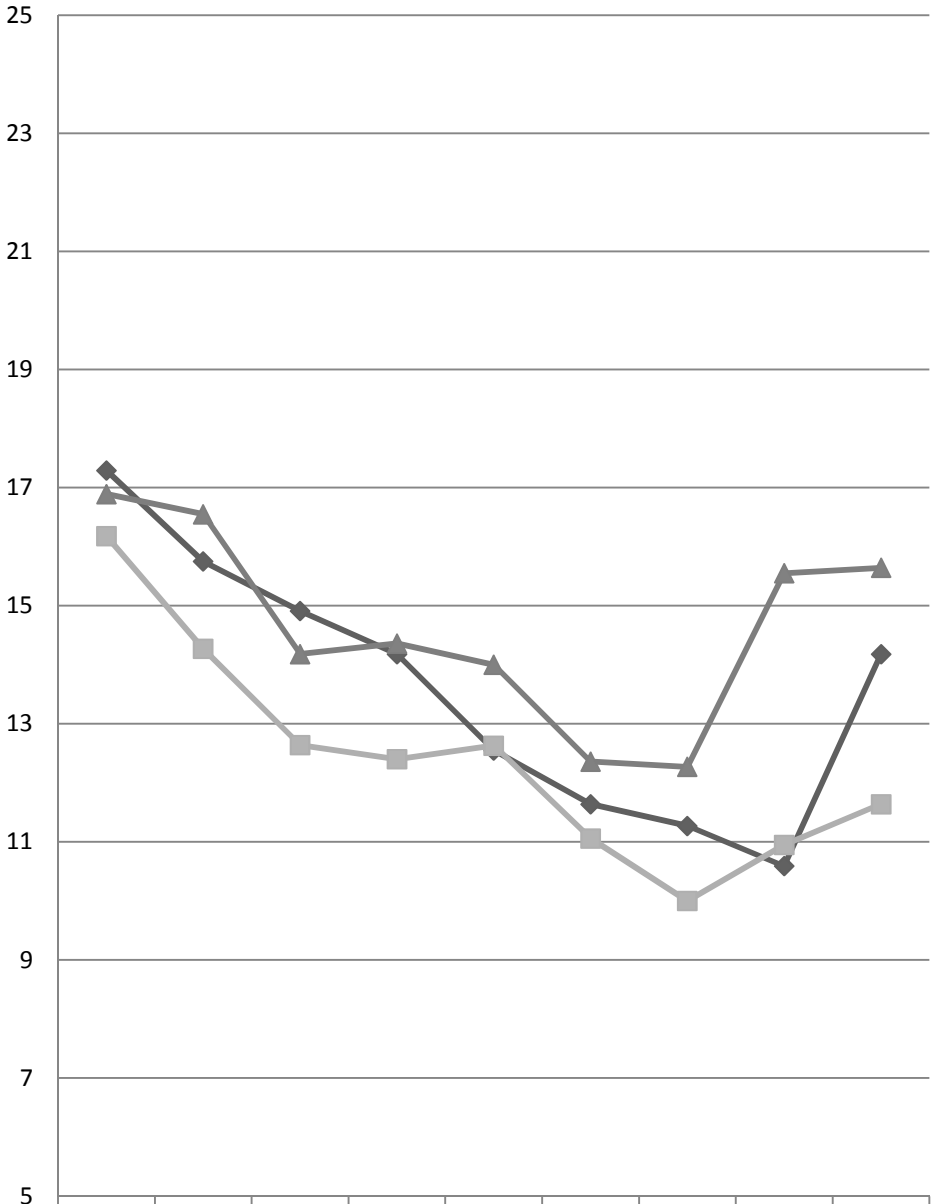
HLM with alternative methods of missing data imputation (Mahalanobis matching method, last observation carried forward, and completers only) suggested that PCL–C numbing scores reduced in a quadratic fashion (all p's < .001). The effect of time in a linear fashion with each imputation method was not statistically significant (all p's > .108), nor was the effects of group membership (all p's > .236), and group and session interaction (all p's > .184). The interaction of group and time using the last observation carried forward method was significant at the $p < .05$ level (i.e., $p = .014$); however, it did not exceed the pre–established significance level for the current study. Differences between group intercepts were not statistically significant; however, the same pattern of between–group differences noted in the predictive mean matching method emerged with the last observation carried forward method. As such, results from alternative methods of data imputation are largely consistent with the predictive mean matching method.

Table 10: PCL–C hyperarousal subscale score means from various imputation methods

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Pre treatment	17.29	—	—	—	16.18	—	—	—	16.89	—	—	—
Session 1	15.75	—	—	—	14.27	—	—	—	16.55	—	—	—
Session 2	14.31	14.91	15.09	14.82	13.10	12.64	12.64	12.55	14.44	14.18	14.55	14.91
Session 3	13.89	14.18	14.64	14.64	12.11	12.40	11.87	12.00	14.67	14.36	14.82	15.09
Session 4	13.48	12.55	13.64	13.36	12.56	12.63	12.21	12.36	14.56	14.00	14.00	15.00
Session 5	12.22	11.64	12.91	12.55	11.11	11.06	11.10	11.18	13.22	12.36	13.00	13.91
Session 6	11.67	11.27	12.73	12.27	10.00	10.00	9.98	10.27	13.00	12.27	12.82	13.73
Week follow–up	13.52	10.59	12.73	12.18	13.60	10.95	12.23	11.64	15.88	15.55	15.18	15.55
Month follow–up	13.87	14.18	14.91	13.09	11.75	11.64	12.91	12.45	15.17	15.64	14.82	15.36

Note: pretreatment and session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

Figure 11: PCL–C hyperarousal subscale score multiply imputed means for total sample and experimental groups.



	1	2	3	4	5	6	7	8	9
cognitive distraction	17.29	15.75	14.91	14.18	12.55	11.64	11.27	10.59	14.18
exercise only	16.18	14.27	12.64	12.4	12.63	11.06	10	10.95	11.64
interoceptive prompts	16.89	16.55	14.18	14.36	14	12.36	12.27	15.55	15.64

Note: X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6, 8 = week follow–up, 9 = month follow–up; Y–axis depicts study group PCL–C hyperarousal score; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

3.4.6 ASI–3 total scores. The predicted means for ASI–3 total scores after session 6 were 22.18, 18.87, and 32.27 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. The main effect of time on ASI–3 total scores was significant in a quadratic ($p < .001$), but not linear fashion ($p = .380$). The interaction between group and time was statistically significant ($p < .001$). The main effect of group membership was not statistically significant ($p=.158$).

Differences in declines of ASI–3 total scores between groups indicated that the slope of decline in ASI–3 total scores among interoceptive prompts group members was significantly less than those in the cognitive distraction ($t[135.06] = –4.39$, $p < .001$) group; differences between the interoceptive prompts and exercise only groups were significant at the $p < .05$ level ($t[205.22]=–2.26$, $p = .025$), but not at the level necessary for statistical significance in the current study. ASI–3 total scores among cognitive distraction group members were also significantly less than in those in the exercise only group ($t[205.22]=4.39$, $p<.001$). Differences between group intercepts were not statistically different from the interoceptive prompts group (cognitive distraction, $t[32.13] = –1.42$, $p < .165$; exercise only, $t[32.13] = –1.90$, $p = .07$). The effect sizes for the change in ASI–3 total scores during the treatment portion of the study for the cognitive distraction ($d = 2.53$), exercise only ($d = .96$), and interoceptive prompts ($d = .69$) groups were large, large, and medium respectively.

Results suggest that ASI–3 total scores reduced in a fashion consistent with an expedited trajectory during in–lab portion of the study. This trend was most marked in the cognitive distraction and exercise only groups, but not as much in the interoceptive prompts or exercise only groups. During the follow–up phase, ASI–3 total scores in the

cognitive distraction and exercise only group rose, but ASI–3 total scores in the interoceptive prompts group remained relatively unchanged during the follow–up phase. The difference in scores at the intercept (after session 6) were not significantly different between groups, but there was a statistically significant difference in slopes wherein the interoceptive prompts group evidenced a less pronounced change.

Given the marked differences in slopes during the in–lab phase of the study displayed in Figure 12, analyses were conducted without follow–up points to discern whether there were differences in slopes. Results suggested that there were significant differences between the interoceptive prompts group and cognitive distraction (t[138.436] = –4.63, $p < .001$). Differences between the interoceptive prompts and exercise only groups were significant at the $p < .05$ level (t[138.44] = –2.51, $p = .013$), but not at the level necessary for statistical significance in the current study. Results suggested that the intervention had a less pronounced effect on ASI–3 total scores in the interoceptive prompts group when compared to the cognitive distraction and exercise only group during the in–lab portion.

HLM with alternative methods of missing data imputation (Mahalanobis matching method, last observation carried forward, and completers only) suggested that ASI–3 total scores reduced in a quadratic fashion (all p's < .001). The effect of time in a linear fashion with each imputation method was not statistically significant (all p's > .137), nor was the effects of group membership (all p's > .213). The interaction between group and session were significant for the Mahalanobis matching method ($p = .010$) and last observation carried forward method ($p = .010$), but the significance level for the completers only method did not exceed the predetermined significance level for the

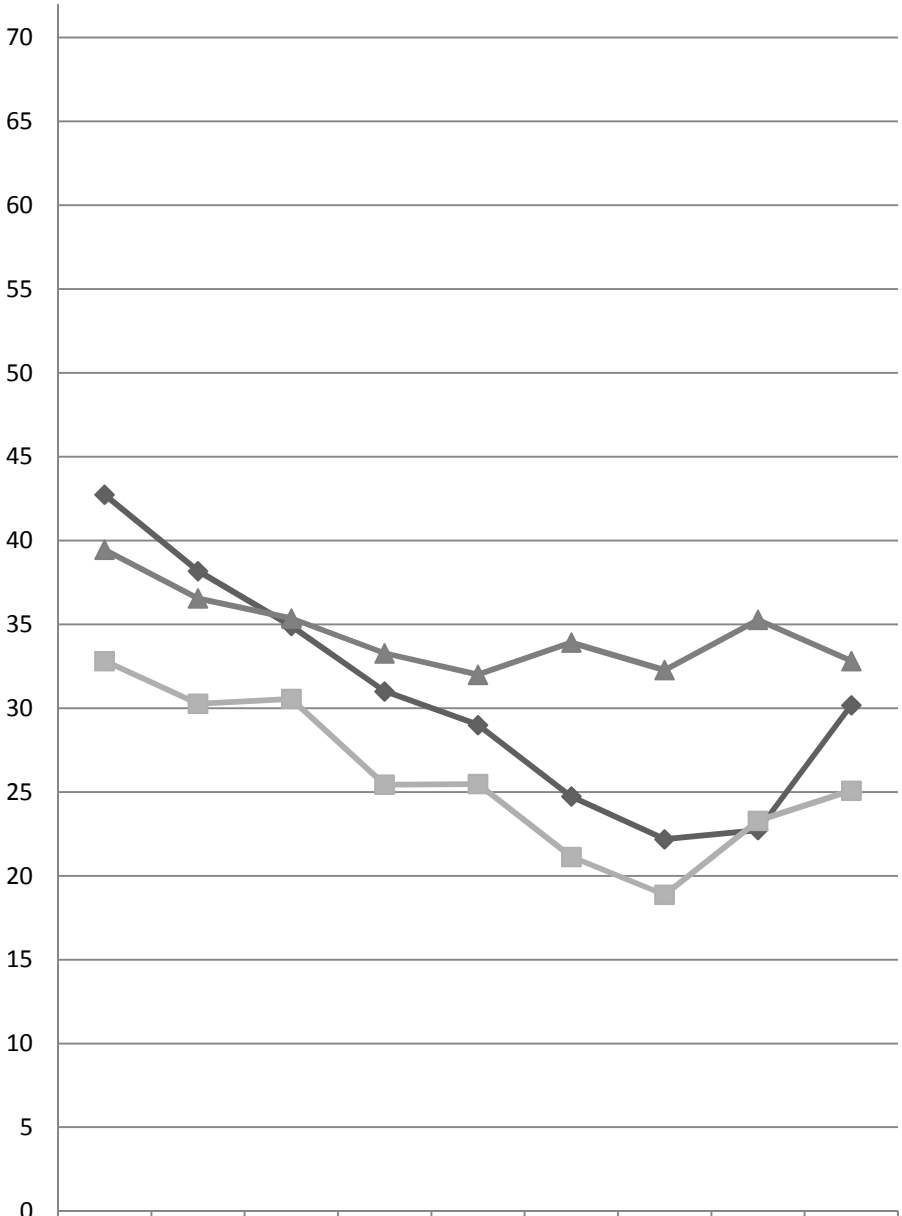
current study (p = .013). As such, results from alternative methods of data imputation are largely consistent with the predictive mean matching method.

Table 11: ASI–3 total score means from various imputation methods

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Pre treatment	42.73	—	—	—	32.82	—	—	—	39.45	—	—	—
Session 1	38.18	—	—	—	30.27	—	—	—	36.55	—	—	—
Session 2	36.80	34.91	35.09	34.45	31.80	30.55	31.91	29.91	34.11	35.36	34.18	34.82
Session 3	34.22	31.00	32.09	32.55	26.33	25.44	26.51	25.18	32.11	33.27	33.18	33.18
Session 4	31.78	29.00	29.82	30.55	26.33	25.48	25.61	25.18	30.22	32.00	32.00	31.64
Session 5	27.22	24.73	24.82	26.82	22.33	21.13	22.52	21.91	31.56	33.91	31.73	32.73
Session 6	25.78	22.18	23.45	25.64	19.56	18.87	20.71	19.64	30.33	32.27	31.09	31.73
Week follow–up	26.50	22.73	23.00	27.55	24.20	23.29	27.76	21.00	32.53	35.27	30.55	32.82
Month follow–up	36.60	30.18	30.73	31.55	16.50	25.09	21.73	21.73	33.00	32.82	32.36	32.27

Note: pretreatment and session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

Figure 12: ASI–3 total score multiply imputed means for total sample and experimental groups.



	1	2	3	4	5	6	7	8	9
cognitive distraction	42.73	38.18	34.91	31	29	24.73	22.18	22.73	30.18
exercise only	32.82	30.27	30.55	25.44	25.48	21.13	18.87	23.29	25.09
interoceptive prompts	39.45	36.55	35.36	33.27	32	33.91	32.27	35.27	32.82

Note: X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6, 8 = week follow–up, 9 = month follow–up; Y–axis depicts study group ASI–3 total score; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

3.4.7 ASI–3 physical concerns. The predicted means for ASI–3 physical scores after session 6 were 4.85, 5.09, and 4.82 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. The effect of time on ASI–3 physical scores was significant in a quadratic ($p < .001$), but not linear fashion ($p = .312$). The effects of group membership were not found to be statistically significant ($p = .895$). The interaction between group and time was statistically significant ($p < .016$). No statistically significant differences in ASI–3 physical between groups were found (all p's > .676). Differences in the slope of decline for ASI–3 total scores between groups indicated that the interoceptive prompts group was significantly less pronounced than the cognitive distraction group ($t[135.06] = –4.39$, $p < .001$). The interoceptive prompts and exercise only groups were significantly different at the $p < .05$ level ($t[205.22] = –2.26$, $p = .025$), but not at the pre–established level for the current study. The effect sizes for the change in ASI–3 physical concerns during the treatment portion of the study for the cognitive distraction ($d = 2.16$), exercise only ($d = .75$), and interoceptive prompts ($d = .87$) groups were large, medium, and large respectively.

Results suggest that ASI–3 physical concerns scores decreased over the course of the six sessions, but that during the follow–up phase, physical concerns elevated. The difference between ASI–3 physical scores was not significantly different between groups after the in–lab portion of the study was complete; however, the trajectory of change appeared to differ between groups. In particular, the interoceptive prompts group demonstrated a less pronounced decrease in ASI–3 physical scores.

HLM with alternative methods of missing data imputation (Mahalanobis matching method, last observation carried forward, and completers only) suggested that

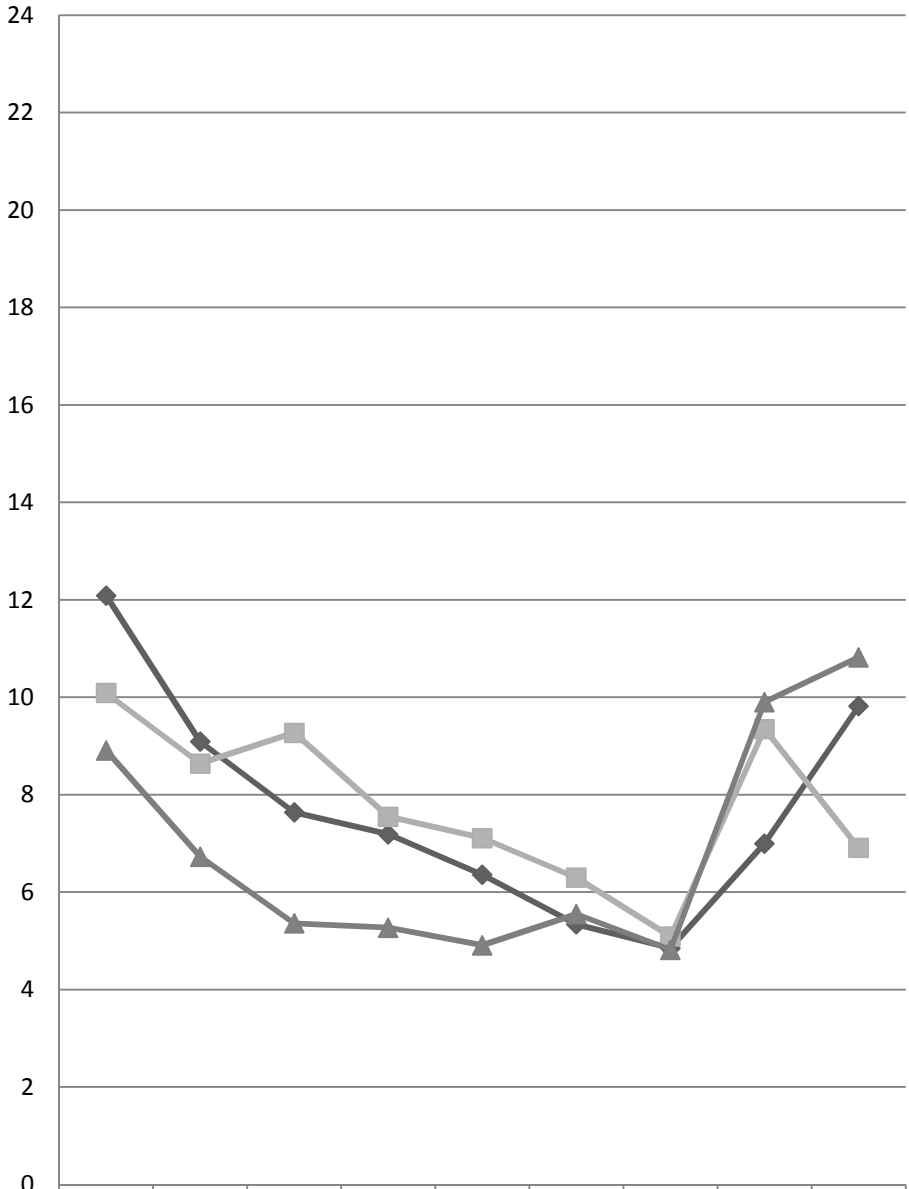
ASI–3 physical scores reduced in a quadratic fashion (all p's < .001). The effect of time in a linear fashion with each imputation method was not statistically significant (all p's > .070), nor was the effects of group membership (all p's > .717). The interaction between group and session was significant for each method used (all p's > .020). Results from each method demonstrated no significant differences in intercepts (all p's > .462); but that the interoceptive prompts group had a significantly reduced slope compared to the cognitive distraction group in each method used (all p's < .006), and the exercise only group when using the last observation carried forward (p = .003) and completers only method (p = .006), but not the mahalanobis method (p = .202). As such, results from alternative methods of data imputation are largely consistent with the predictive mean matching method.

Table 12: ASI–3 physical concerns subscale score means from various imputation methods

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Pre treatment	12.09	—	—	—	10.09	—	—	—	8.91	—	—	—
Session 1	9.09	—	—	—	8.64	—	—	—	6.73	—	—	—
Session 2	8.40	7.64	7.82	7.64	10.20	9.27	9.55	9.27	4.78	5.36	5.27	6.36
Session 3	7.67	7.19	7.23	7.18	7.67	7.55	7.80	7.82	4.56	5.27	5.18	6.18
Session 4	6.56	6.36	6.31	6.27	7.44	7.11	7.34	7.64	4.44	4.91	4.82	6.09
Session 5	5.33	5.34	5.36	5.27	6.89	6.30	7.10	7.18	5.67	5.55	5.55	7.09
Session 6	5.00	4.85	4.90	5.00	5.56	5.09	5.45	6.09	4.78	4.82	4.82	6.36
Week follow–up	8.33	7.00	8.09	7.82	7.80	9.35	11.04	6.64	10.88	9.90	10.59	10.73
Month follow–up	11.33	9.82	9.73	9.73	5.25	6.91	11.18	7.27	12.17	10.82	9.45	11.00

Note: pretreatment and session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

Figure 13: ASI–3 physical subscale score multiply imputed means for total sample and experimental groups.



	1	2	3	4	5	6	7	8	9
cognitive distraction	12.09	9.09	7.64	7.19	6.36	5.34	4.85	7	9.82
exercise only	10.09	8.64	9.27	7.55	7.11	6.3	5.09	9.35	6.91
interoceptive prompts	8.91	6.73	5.36	5.27	4.91	5.55	4.82	9.9	10.82

Note: X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6, 8 = week follow–up, 9 = month follow–up; Y–axis depicts study group ASI–3 physical score; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

3.4.8 ASI–3 cognitive concerns. The predicted means for ASI–3 cognitive scores after session 6 were 8.82, 6.76, and 8.18 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. The main effect of time on ASI–3 cognitive scores was significant in a linear (p = .001), but not quadratic fashion (p = .087). The main effect of group membership was not statistically significant (p = .697). The interaction between group and time was not statistically significant (p < .859). The effect sizes for the change in ASI–3 cognitive scores during the treatment portion of the study for the cognitive distraction (d = 1.46), exercise only (d = .91), and interoceptive prompts (d = 1.13) groups were all large.

Results suggest that ASI–3 cognitive scores decreased in a linear fashion over the course of the in–lab portion of the study. The decline in ASI–3 cognitive scores continued into the week follow–up, but scores elevated during the month follow–up. Findings indicated no differences between groups in terms of intercept or rate of change during the study.

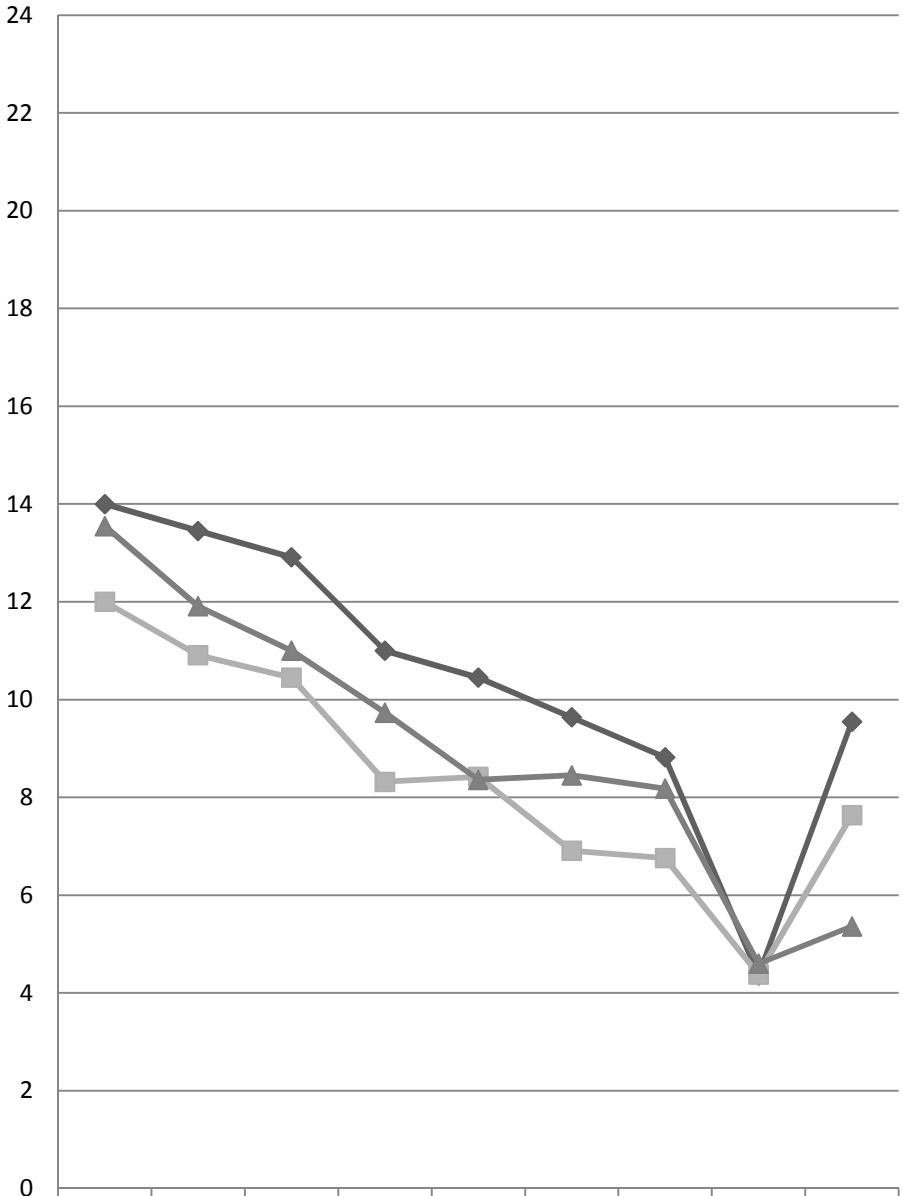
HLM with alternative methods of missing data imputation (Mahalanobis matching method, last observation carried forward, and completers only) suggested that ASI–3 cognitive scores reduced in a linear fashion (all p's < .001). The effect of time in a quadratic fashion with each imputation method was not statistically significant (all p's > .233), nor was the effects of group membership (all p's > .448) and the interaction between group and time (all p's > .809). As such, results from alternative methods of data imputation are largely consistent with the predictive mean matching method.

Table 13: ASI–3 cognitive concerns subscale score means from various imputation methods

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Pre treatment	14.00	—	—	—	12.00	—	—	—	13.55	—	—	—
Session 1	13.45	—	—	—	10.91	—	—	—	11.91	—	—	—
Session 2	14.10	12.91	12.91	12.82	11.40	10.45	11.09	10.82	11.67	11.00	10.91	10.82
Session 3	12.22	11.00	11.65	11.45	9.33	8.32	8.65	8.45	10.11	9.73	9.36	9.55
Session 4	11.89	10.45	11.32	11.18	9.00	8.42	8.33	8.18	8.89	8.36	8.27	8.55
Session 5	10.44	9.64	10.46	10.00	7.78	6.91	7.37	7.18	9.00	8.45	8.64	8.64
Session 6	9.56	8.82	9.86	9.27	6.78	6.76	6.77	6.36	8.67	8.18	8.55	8.36
Week follow–up	5.63	4.36	5.55	6.73	7.20	4.38	5.77	6.91	5.25	4.60	5.73	5.27
Month follow–up	8.20	9.55	7.82	8.00	7.75	7.64	5.27	7.00	3.67	5.36	6.00	4.64

Note: pretreatment and session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

Figure 14: ASI–3 cognitive subscale score multiply imputed means for total sample and experimental groups.



	1	2	3	4	5	6	7	8	9
cognitive distraction	14	13.45	12.91	11	10.45	9.64	8.82	4.36	9.55
exercise only	12	10.91	10.45	8.32	8.42	6.91	6.76	4.38	7.64
interoceptive prompts	13.55	11.91	11	9.73	8.36	8.45	8.18	4.6	5.36

Note: X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6, 8 = week follow–up, 9 = month follow–up; Y–axis depicts study group ASI–3 cognitive score; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

3.4.9 ASI–3 social concerns. The predicted means for ASI–3 social scores after session 6 were 10.42, 6.56, and 16.18 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. The main effect of time on ASI–3 social scores was significant in a quadratic (p = .002), but not linear fashion (p = .252). The interaction between group and time was statistically significant (p = .006). The main effect of group membership on ASI–3 social scores was statistically significant (p = .003). Differences in the slope of decline for ASI–3 total scores between groups indicated that the interoceptive prompts group was significantly less pronounced than the cognitive distraction (t[176.58] = –3.24, p = .001) and exercise only (t[176.58] = –1.53, p = .127) groups. Differences between group ASI–3 physical score intercepts (session 6) were significantly different from the interoceptive prompts group (cognitive distraction, t[31.05] = –2.14, p = .040; exercise only, t[31.05] = –3.72, p = .001). The effect sizes for the change in ASI–3 social scores during the treatment phase of the study for the cognitive distraction (d = 2.20), exercise only (d = 1.01), and interoceptive prompts (d = .24) groups were large, large, and small respectively.

Results suggest that ASI–3 social scores decreased over the course of the in–lab portion of the study, but decelerated during the follow–up phases. Findings also indicated that group membership was important for reductions in ASI–3 social scores, wherein the interoceptive prompts group had a less pronounced trajectory of ASI–3 social scores, and greater ASI–3 social scores at the end of the in–lab portion of the study.

HLM with alternative methods of missing data imputation (Mahalanobis matching method, last observation carried forward, and completers only) suggested that ASI–3 total scores reduced significantly in a quadratic fashion, at the $p < .05$ level, when

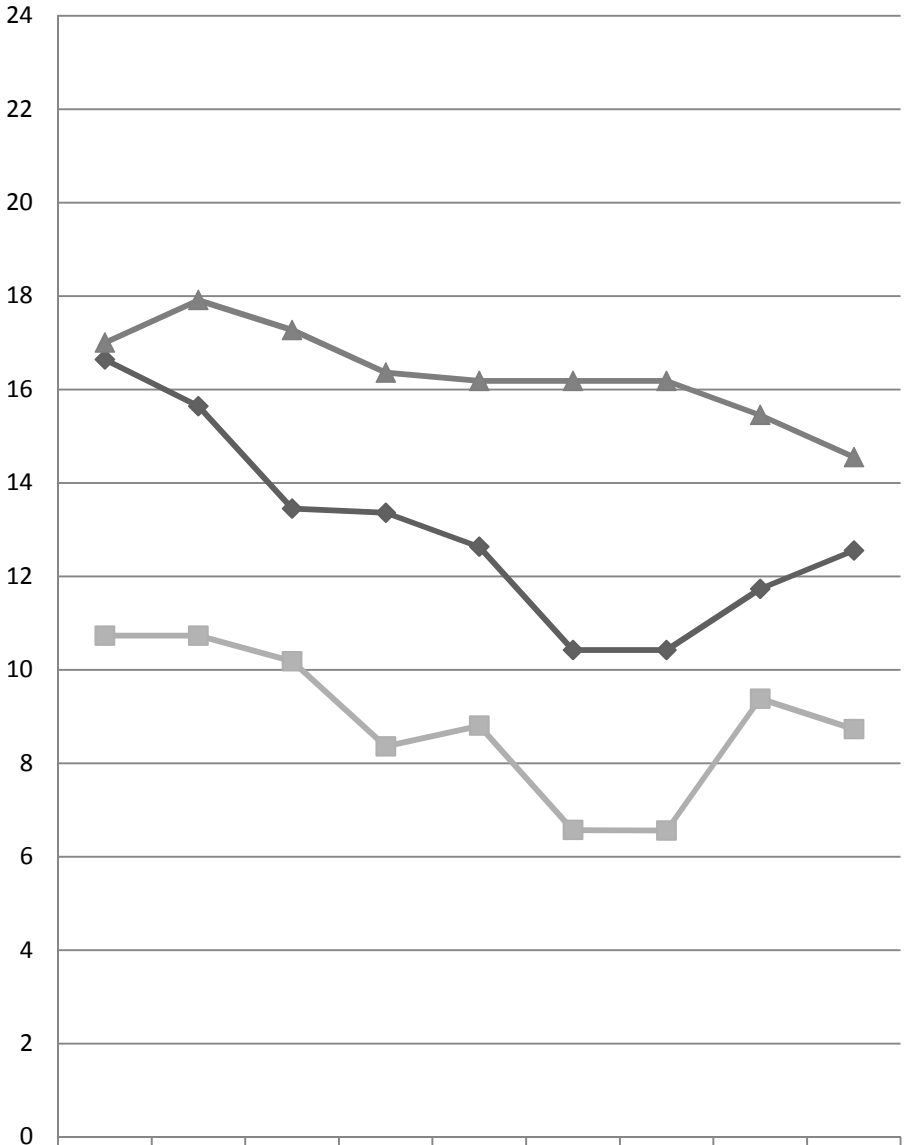
using the mahalanobis matching method (p = .019) and last observation carried forward method (p = .014), but not the completers only method (p = .133). The effect of time in a linear fashion was not statistically significant when using each method of data imputation (all p's > .070). The effect of group membership was significant with each method (all p's < .007) as was the interaction between group and time (all p's < .006). Each method of data imputation suggested significant differences in intercepts wherein the interoceptive prompts group reported significantly higher ASI–3 social scores than the cognitive distraction (all p's > .047) and exercise only groups (all p's > .002). Likewise, each data imputation method suggested significant differences in slopes wherein the interoceptive prompts group reported significantly less pronounced declines in ASI–3 social scores than the cognitive distraction (all p's > .014); differences between the interoceptive prompts group and the exercise only group were significant when using the completers only method (p = .009), but not the last observation carried forward method (p = .140) or the mahalanobis matching method (p = .615). As such, results from alternative methods of data imputation are largely consistent with the predictive mean matching method.

Table 14: ASI–3 social concerns subscale score means from various imputation methods

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Pre treatment	16.64	—	—	—	10.73	—	—	—	17.00	—	—	—
Session 1	15.64	—	—	—	10.73	—	—	—	17.91	—	—	—
Session 2	14.30	13.45	14.18	14.00	10.20	10.18	10.09	9.82	17.67	17.27	17.64	17.64
Session 3	14.33	13.36	14.00	13.91	9.33	8.36	9.52	8.91	17.44	16.36	17.09	17.45
Session 4	13.33	12.63	13.27	13.09	9.89	8.80	9.57	9.36	16.89	16.18	16.82	17.00
Session 5	11.44	10.42	11.18	11.55	7.67	6.57	8.68	7.55	16.89	16.18	16.73	17.00
Session 6	11.22	10.42	11.00	11.36	7.22	6.56	8.22	7.18	16.89	16.18	16.36	17.00
Week follow–up	12.25	11.73	12.36	12.82	9.20	9.38	11.50	7.45	16.50	15.45	16.82	16.82
Month follow–up	16.40	12.55	12.45	13.64	3.50	8.73	10.64	7.45	17.17	14.55	18.45	16.64

Note: pretreatment and session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

Figure 15: ASI–3 social subscale score multiply imputed means for total sample and experimental groups.



	1	2	3	4	5	6	7	8	9
cognitive distraction	16.64	15.64	13.45	13.36	12.63	10.42	10.42	11.73	12.55
exercise only	10.73	10.73	10.18	8.36	8.8	6.57	6.56	9.38	8.73
interoceptive prompts	17	17.91	17.27	16.36	16.18	16.18	16.18	15.45	14.55

Note: X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6, 8 = week follow–up, 9 = month follow–up; Y–axis depicts study group ASI–3 social score; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

3.4.10 CES–D scores. The predicted means for CES–D scores after session 6 were 41.73, 41.84, and 44.18 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. The main effect of time on CES–D cognitive scores was significant in a quadratic ($p = .002$), but not a linear fashion ($p = .456$). The interaction between group and time was not statistically significant ($p < .212$). The main effect of group membership on CES–D scores was not statistically significant ($p = .833$). The effect sizes for the change in CES–D scores during the treatment phase of the study for the cognitive distraction ($d = .87$), exercise only ($d = .42$), and interoceptive prompts ($d = 1.02$) groups were large, small, and large respectively.

Results suggest that CES–D scores decreased during the in–lab portion of the study, but increased during the follow–up phase. Findings also indicated that group membership did not have an effect on CES–D scores. Specifically, there was no difference in the trajectory of change, or the intercepts (session 6) of CES–D scores.

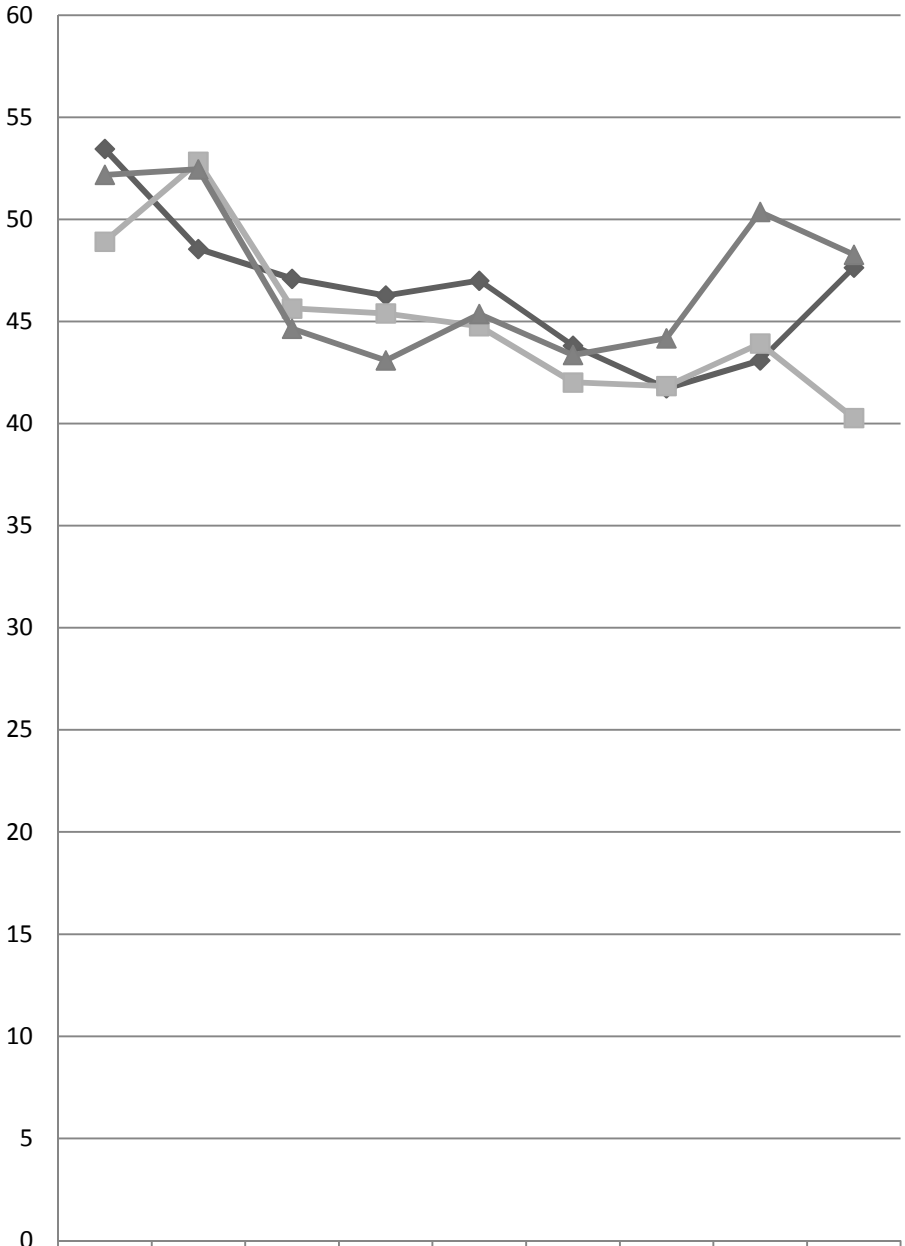
HLM with alternative methods of missing data imputation (Mahalanobis matching method, last observation carried forward, and completers only) suggested that CES–D scores reduced in a quadratic fashion (all p's $< .001$). The effect of time in a linear fashion with each imputation method was not statistically significant when utilizing completers only and last observation carried forward method (all p's $> .214$), but was statistically significant using the mahalanobis matching method ($p = .006$). The effects of group membership (all p's $> .839$) and the interactions between time and group membership (all p's $> .230$) were not statistically significant when each method was used. As such, results from alternative methods of data imputation are largely consistent with the predictive mean matching method.

Table 15: CES–D score means from various imputation methods

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Pre treatment	53.45	—	—	—	48.91	—	—	—	52.18	—	—	—
Session 1	48.55	—	—	—	52.82	—	—	—	52.45	—	—	—
Session 2	48.60	47.09	47.27	46.82	45.50	45.64	46.55	46.45	45.44	44.64	46.45	45.27
Session 3	47.22	46.27	47.55	46.09	47.00	45.39	47.15	47.18	44.11	43.09	45.45	44.18
Session 4	46.00	47.00	45.45	45.09	45.44	44.77	46.68	45.91	45.67	45.36	46.82	45.45
Session 5	43.44	43.82	43.00	43.00	42.78	42.02	44.98	43.73	44.44	43.36	45.09	44.45
Session 6	40.33	41.73	40.73	40.45	41.44	41.84	43.98	42.64	44.44	44.18	44.82	44.45
Week follow–up	40.38	43.09	44.82	42.00	50.40	43.92	54.19	47.00	50.50	50.36	51.91	48.00
Month follow–up	50.00	47.64	50.55	46.18	34.75	40.27	50.64	47.55	51.50	48.27	49.18	46.55

Note: pretreatment and session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

Figure 16: CES–D score multiply imputed means for total sample and experimental groups.

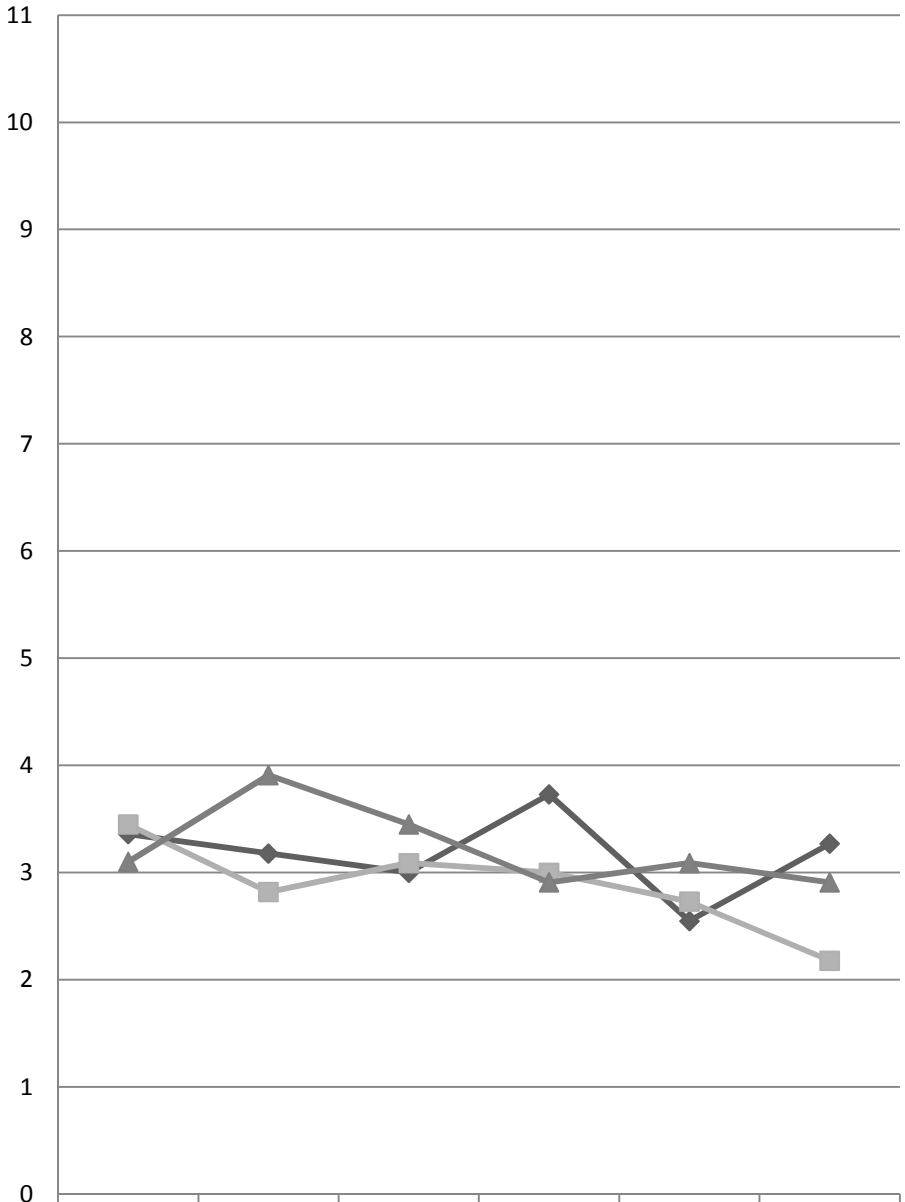


	1	2	3	4	5	6	7	8	9
cognitive distraction	53.45	48.55	47.09	46.27	47	43.82	41.73	43.09	47.64
exercise only	48.91	52.82	45.64	45.39	44.77	42.02	41.84	43.92	40.27
interoceptive prompts	52.18	52.45	44.64	43.09	45.36	43.36	44.18	50.36	48.27

Note: X axis depicts assessment point (1 = pretreatment, 2 = session 1, 3 = session 2, 4 = session 3, 5 = session 4, 6 = session 5, 7 = session 6, 8 = week follow–up, 9 = month follow–up; Y–axis depicts study group CES–D score; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

3.4.11 Trauma–related memories. The predicted means for trauma–related memories elicited after session 6 were 2.55, 2.73, and 3.09 for the cognitive distraction, exercise only, and interoceptive prompts groups respectively. The main effect of time in a linear (p = .319) and quadratic fashion (p = .539), the main effect of group membership (p = .945), and the interaction between group and time (p = .878) were all not statistically significant. Results suggest that the intervention did not have an effect on eliciting and reducing trauma–related memories throughout the course of the study.

Figure 17: Trauma–related memories elicited by the exercise session multiply imputed means for total sample and experimental groups.



	1	2	3	4	5	6
cognitive distraction	3.36	3.18	3	3.73	2.55	3.27
exercise only	3.45	2.82	3.09	3	2.73	2.18
interoceptive prompts	3.1	3.91	3.45	2.91	3.09	2.91

Note: X axis depicts assessment point (1 = session 1, 2 = session 2, 3 = session 3, 4 = session 4, 5 = session 5, 6 = session 6); Y–axis depicts study group trauma–related memories; scores on Y–axis depict multiply imputed scores using the predictive mean matching method.

Table 16: Means of trauma–related memories elicited from various imputation methods

	Cognitive distraction				Exercise only				Interoceptive prompts			
	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI	CO	MI_a	MI_b	SI
Session 1	3.36	—	—	—	3.45	—	—	—	3.10	—	—	—
Session 2	3.60	3.18	3.82	3.36	3.30	2.82	3.09	3.09	3.44	3.91	3.91	3.45
Session 3	3.78	3.00	3.64	3.27	3.22	3.09	3.36	2.91	3.44	3.45	3.55	3.45
Session 4	3.56	3.73	3.82	3.09	4.22	3.00	3.73	3.73	2.89	2.91	2.91	3.00
Session 5	2.67	2.55	3.09	2.36	3.78	2.73	3.27	3.36	2.89	3.09	3.00	3.00
Session 6	2.78	3.27	3.00	2.45	3.89	2.18	3.36	3.45	2.56	2.91	2.64	2.73

Note: session1 data did not include any missing values, therefore, values are identical for each imputation method. MI = Multiple imputation; $_a$ = predictive mean matching method; $_b$ = mahalanobis distance matching method; SI = Single imputation (last–observation–carried–forward); CO = completers only.

3.5 Secondary Statistical Analyses

A paired samples *t*–test was performed to assess differences between self–reported physical activity engagement (vigorous activity engagement, moderate physical activity engagement, intensity of physical activity engagement, past week physical activity engagement, and general impression of physical fitness) and lifestyle (distance from ideal body weight, sleep, ability to cope with stress, and ability to relax) factors between the initial screen and one–week follow–up. Table 17 summarizes the means for each variable at both the online screen and one week follow–up. Results suggest that only distance from ideal body weight was significantly different between time periods ($t[20] = –2.2.17$, $p = .04$), such that participants rated themselves as significantly further from their ideal weight after completing the study. The remaining variables including vigorous activity engagement ($t[15] = –1.83$, $p = .09$), moderate physical activity engagement ($t[18] = –2.1$, $p = .05$), intensity of physical activity engagement ($t[20] = .15$, $p = .89$), past week physical activity engagement ($t[18] = .00$, $p = 1.00$), general impression of physical fitness ($t[20] = –1.75$, $p = .10$), sleep ($t[20] = .40$, $p = .69$), ability to cope with stress ($t[20] = .00$, $p = 1.00$), and ability to relax ($t[20] = .00$, $p = 1.00$) did not significantly differ between the initial screening and one–week follow–up time periods.

Table 17. Mean physical fitness and lifestyle variables at initial screen and one week follow–up

		Initial screen		One week follow–up	
	n	*M*	*SD*	*M*	*SD*
Physical activity variables					
Vigorous activity engagement	16	1.5	.63	2.00	1.21
Moderate physical activity engagement	19	3.26	1.48	3.95	1.22
Intensity of physical activity engagement	21	2.86	.85	2.81	1.08
Past week physical activity engagement	19	1.84	1.01	1.84	.89
General impression of physical fitness	21	2.67	.91	2.90	.94
Lifestyle factors					
Distance from ideal body weight	21	2.86	1.46	3.24	1..61
Sleep	21	2.52	1.21	2.43	1.25
Ability to cope with stress	21	3.00	.63	3.00	1.18
Ability to relax	21	2.76	.62	2.76	.94

M = Mean, SD = Standard Deviation, n = Number of participants included analysis.

3.6 Assessing for Clinically Significant Change.

3.6.1 Clinically significant changes in PCL–C scores. Consistent with guidelines put forth by the National Center for PTSD (2007), participants were classified as showing clinically significant change if (1) they reported a reduction in PCL–C total score of greater than 10. These analyses were completed after session 6, and at the one week, and one month follow–ups. Each score was compared to the initial online screen scores. After session 6, 24 participants (88.9%) reported clinically significant reductions in PCL–C scores. Participants who dropped out before session 6 had a mean PCL–C reduction of 5.13 (range: –10.5 to 23). At the one–week follow–up, 16 of the 21 (76.2%) participants reported a reduction in PCL–C scores compared to their pre–treatment scores; however, only 3 (14.3%) were clinically significant. Participants who dropped out between session 6 and the one week follow–up had a mean PCL–C reduction of 17 (range: 5 to 35). At the one month follow–up, 13 of the 15 participants (86.7%) reported a reduction in PCL–C scores compared to their pre–treatment scores; however, only 1 (6.7%) was clinically significant. Participants who dropped out between the one week and one month follow–ups had a mean PCL–C reduction of 8.57 (range: –29 to 40).

3.6.2 Clinically significant changes in ASI–3 scores. Consistent with guidelines put forth Jacobson and Traux (1990), participants were classified as showing clinically significant change if they reported a reduction in ASI–3 scores of greater than 2 standard deviations in the online screen (i.e., >29). Analyses were completed after session 6, and at the one week, and one month follow–ups. After session 6, 23 of the 27 participants (85.2%) reported a reduction in ASI–3 total scores; however, only 4 (14.8%) were clinically significant. Participants who dropped out before session 6 had a mean ASI–3

reduction of 7.8 (range: –7 to 23). At the one–week follow–up, 16 of the 21 participants (76.2%) reported a reduction in ASI–3 scores compared to their pre–treatment scores; however, only 3 (14.3%) were clinically significant. Participants who dropped out between session 6 and the one week follow–up had a mean ASI–3 reduction of 12 (range: –10 to 49). At the one month follow–up, 13 of the 15 participants (87.6%) reported a reduction in ASI–3 scores compared to their pre–treatment scores; however, only 1 (6.7%) was clinically significant. Participants who dropped out between the one week and one month follow–ups had a mean ASI–3 reduction of 3.86 (range: –35 to 35).

3.6.3 Clinically significant changes in CES–D scores. Consistent with guidelines put forth Jacobson and Traux (1990), participants were classified as showing clinically significant change if they reported a reduction in CES–D total scores of greater than 2 standard deviations in the online screen (i.e., >12). Analyses were completed after session 6, and at the one week, and one month follow–ups. Completer sample included all study members who completed the specific phase of treatment. After session 6, 15 of the 27 participants (55.6%) reported a reduction in CES–D total scores; however, only 4 (14.8%) were clinically significant. Participants who dropped out before session 6 had a mean CES–D reduction of 5.5 (range: –15 to 2). At the one–week follow–up, 11 of the 20 participants (55%) reported a reduction in CES–D scores compared to their pre–treatment scores; however, only 5 (20%) were clinically significant. Participants who dropped out between session 6 and the one week follow–up had a mean CES–D reduction of 9.1 (range: –13 to 27). At the one month follow–up, 8 of the 14 participants (57.1%) reported a reduction in CES–D scores compared to their pre–treatment scores; however, only 2

(14.3%) were clinically significant. Participants who dropped out between the one week and one month follow–ups had a mean CES–D increase of .14 (range: –41 to 36).

4. Discussion

The purpose of the current study was to assess whether a brief aerobic exercise intervention would be successful in reducing PTSD symptoms and, if so, determine the anxiolytic mechanisms involved. Four predictions were made: (1) participants, regardless of group membership, were expected to report a statistically significant reduction in PTSD symptoms, AS dimension scores, and depressive symptoms over the course of the six sessions of treatment and throughout the follow–up period; (2) although scores were not expected to differ between groups at pre–treatment, participants in the interoceptive prompts group were expected to have statistically significantly lower PTSD symptoms, AS dimension scores, and depressive symptoms than the cognitive distraction and exercise only groups after session six and throughout the follow–up periods; (3) participants in the interoceptive prompts group, but not the cognitive distraction or exercise only groups, were expected to have clinically significant reductions in PTSD symptoms after session six, and throughout the follow–up periods; and (4) participants in the interoceptive prompts group, but not the cognitive distraction or exercise only groups, were expected to demonstrate statistically significant drops in trauma–related memories brought on by the physical exercise. To follow is a comprehensive discussion of the results as they pertain to the aforementioned hypotheses. In addition, explanation of secondary findings will be discussed, including: (1) motivation to enter and continue with the treatment, (2) subjective reactions to exercise sessions (i.e., focus on physiological sensations, difficulty, and enjoyment), (3) success of group attention tasks, (4) attrition throughout the study, psychopathologies in the current sample, and (5) physical fitness

prior to and after the exercise treatment. The section will conclude with a discussion on the limitations of the current research as well as clinical and theoretical relevance.

4.1 Primary Findings

4.1.2 Hypothesis 1: Was the intervention effective? Hypothesis 1 predicted that participants would report statistically significant reductions in PTSD symptoms, AS dimension scores, and depressive symptoms over the course of the six sessions of treatment and throughout the follow–up period; results indicated that this hypothesis was confirmed. Specifically, participants reported reductions in each of the PTSD symptom clusters, all AS dimension scores, and depressive symptoms over the course of the six treatments. These findings were considered reliable given the strength of significance, size of effect sizes, and concurrence with alternative data imputation methods.

The aerobic exercise intervention employed in the current study was effective in reducing PTSD severity and symptoms. A similar trend was witnessed among each symptom cluster, as well as in overall PTSD severity, wherein self–reported PCL–C scores tended to decrease markedly during the in–lab portion of the study and then increase during the follow–up phases. In most cases, the decline in self–reported symptom severity was uniform throughout the treatment phase, showing little detraction from a steady downward trend. This decline invariably reversed however, between the sixth session and one–week follow–up suggesting that although the intervention was effective, the effects were unstable once the intervention stopped. This is not surprising given that the majority of our sample indicated during the follow–up phase that they had returned back to their previously inactive lifestyle.

The most impacted PTSD symptom cluster was PTSD hyperarousal symptoms, as the effect sizes for each group were larger in comparison to that demonstrated in other symptom clusters. The effective targeting of hyperarousal symptoms is likely due to the implicit exposure to anxiety–like sensations–which overlap with many hyperarousal symptoms (APA, 2013)–during aerobic exercise. It may have been the case the aerobic exercise acted as a type of interoceptive exposure which has been shown to reduce PTSD symptoms in previous studies (e.g., Wald & Taylor, 2008). Alternatively, the aerobic exercise may have provided participants with an effective outlet for frustrations or depleted energy stores in sufficient amounts to decrease hyperarousal and even encourage sleep. These possibilities are recognized by–products of aerobic exercise (Lamarch & De Koninck, 2007; Ohayon, 2005; Ross, Ball, Sullivan, & Caroff, 1989; Spoormaker & van den Bout, 2005) and would also counter PTSD symptoms, thereby providing therapeutic benefits.

Although not as large across groups as hyperarousal symptoms, effect sizes of declines in re–experiencing, avoidance, and numbing symptoms were also impressive. More specifically, all effect sizes were large with the exception of medium effect sizes in avoidance and numbing symptoms among interoceptive prompts group members. The decline in re–experiencing, avoidance, and numbing symptoms may have been due to simultaneous targeting of cognitive and behavioral aspects of posttraumatic stress disorder which are subsumed under these symptom clusters. Indeed, the aerobic exercise may have provided a type of cognitive restructuring wherein participants were able to accomplish a difficult task (i.e., completing a difficult aerobic exercise regimen) thus providing confidence that they would be able to cope with difficult cognitive (e.g.,

distress arising from unintentional re–experiencing of the traumatic event) and behavioral (e.g., fear causing avoidance of situations reminding them of the traumatic event) PTSD symptoms.

Given the recent release of DSM–5, a discussion of issues pertaining to novel PTSD symptoms may provide further understanding of the current study in the context of the evolution of PTSD. To begin, the current study utilized a number of facets which are consistent within DSM–5. First, each of our participants reported experiencing a traumatic event which was consistent with DSM–IV–TR criteria; DSM–5 however, has dropped the necessary qualifier for individuals to have had feeling of intense fear, helplessness or horror, engendered by the event. Given that DSM–5 has expanded the criteria necessary for traumatization, each of our participants would still be eligible for the study if we had used DSM–5 trauma criteria. Moreover, the current study was consistent with DSM–5 changes in that a four–factor structure was employed rather than the three–factor structure of DSM–IV–TR. Our measure of PTSD, the PCL–C, was also advantageous given that items are taken directly from the PTSD symptom criteria. The disadvantage of this was that we were unable to include the additional symptoms which were added to the numbing and hyperarousal symptom clusters of the DSM–5. The consequence of this omission is that we cannot determine the effect of aerobic exercise on the newly added symptoms.

Depressive symptoms declined in a similar fashion as PTSD symptoms during the course of the study. The strength of this decline was also similar to that of PTSD symptoms. Findings reinforce the connection between PTSD and depressive symptomology (e.g., Beck, DeMond, & Palyo, 2009). The aerobic exercise intervention

may have worked as a type of behavioral activation (i.e., getting depressed individuals active and participating in engaging activities), or engaged anti–depressant neurochemical changes which have been proposed in past research (e.g., Cotman, & Engesser–Cesar, 2002). Such working mechanisms may have impacted PTSD and depressive symptoms alike.

Like PTSD severity and symptoms, AS severity and dimensions reduced significantly over the course of the study; however, the trend of decline was slightly different. Reductions in physical concerns mirrored that which was seen in PTSD symptoms, specifically, symptoms declined in a steady fashion during the in–lab portion and escalated during the follow–up phase. This connection is not surprising given that physical concerns have been noted in previous literature to be the most closely linked to PTSD symptoms when compared to other AS dimensions, especially hyperarousal (Fetzner et al., 2011). Such findings also reinforce the effectiveness of targeting of feared physiological sensations when treating PTSD, which is the focus of interoceptive exposure (e.g., Wald & Taylor, 2008).

Outcomes from the cognitive and socially observable fears were unique among primary variables examined in the current study. Cognitive fears were the only variable found to reduce in a linear, and not a quadratic fashion. Furthermore, cognitive fears continued to decline during the follow–up phase of the study. Such results suggest that although aerobic exercise appeared to target physiological fears, the decline in cognitive fears showed greater robustness over time. It may have been the case that the proposed cognitive restructuring had less to do with the continuation of the aerobic exercise

whereas targeting fears of physiological sensations required greater amounts or longer duration of intervention.

Socially observable symptoms were the only primary variable to evidence an effect of group membership. Furthermore, the strength of the decline in socially observable symptoms was quite different between groups, with the cognitive distraction group having the strongest effect size out of all primary variables, and the interoceptive promtps group having the weakest. The volatility of the findings with regards to socially observable symptoms may have had little impact on the reduction in PTSD symptoms given that they have been found to be the least strongly connected with PTSD symptoms in previous research (e.g., Fetzner et al., 2011). Notwithstanding, findings with regards to social concerns reinforce that there were subtle differences between study groups.

4.1.3 Hypothesis 2: What were the mechanisms of change? Hypothesis 2 predicted that participants in the interoceptive prompts group would report statistically significantly lower PTSD symptoms, AS dimension scores, and depressive symptoms than the cognitive distraction and exercise only groups after session six and throughout the follow–up periods. Results did not support this hypothesis and it was, therefore, rejected. More specifically, results suggested that, with the exception of ASI–3 social, group membership did not have an effect on primary outcome variables. Moreover, when assessing the interaction between group membership and time, results suggested that there was either no difference between groups (i.e., depression, AS cognitive concerns, and PTSD re–experiencing, avoidance, and numbing) or that the interoceptive prompts groups reported less pronounced reductions in primary outcome variables (i.e., AS social concerns, AS physical concerns, PTSD hyperarousal smymptoms).

The findings with regards to group membership suggest that there was no difference in anxiolytic effects that were due to the effect of group membership alone (except for the case of AS social concerns which is addressed below). The influence of group acted in conjunction with increased exposure to the aerobic exercise program in variables which focused on threatening physiological sensations (i.e., AS physical concerns and hyperarousal symptoms). Arguably, given that past research has demonstrated strong associations between PTSD hyperarousal symptoms and AS physical concerns (Asmundson & Stapleton, 2008; Collimore, McCabe, Carleton, & Asmundson, 2008; Fetzner et al., 2011), an explanation for such findings may overlap. Counter to expectations prior to commencing the study, increasing the participants' focus on their feared physiological sensations did not lead to a decrease in such variables. It may have been the case that our introductory videos did not provide enough of an explanation as to the purpose to why this study protocol was in place, or perhaps our dose of treatment was insufficient to exact the full anxiolytic effect among the interoceptive prompts group. At any rate, the cognitive distraction group tended to fare best in these variables. In all likelihood, each group was receiving implicit interoceptive exposure causing a decrease in physiological arousal and fear of such symptoms. The difference between groups may have come from the fact that in the cognitive distraction group, and to a lesser extent the exercise only group, the task was made less threatening.

AS social was an anomaly among primary outcome variables because group membership had a significant effect on AS social scores. There was also an interaction between group membership and amount of time in the study. Results suggested that the interoceptive prompts group fared worse than the other two groups. The reason for this

may have been similar to the previous explanation–the interoceptive prompts group task may have been socially threatening. Indeed, having physically untrained individuals exercise while watching themselves on screen, in the presence of a physical trainer, may have been awkward and threatening for most. Perhaps with a more thorough explanation of the rationale behind this study task, or even with an increased dosage, participants may have seen a greater decline in AS social symptoms. As is however, it appears that the less threatening the task was made for the participants and the less they had to think about the difficulty of the task, the more effective it was at reducing their fears of socially observable symptoms.

The majority of PTSD symptoms (i.e., re–experiencing, avoidance, and numbing) and AS cognitive concerns did not evidence significant effects of group membership or any interaction between group membership and time. These suggest that common factors may be responsible for much of the anxiolytic effect witnessed during the current study. Although specific naming of such factors is not possible given the current data, speculatively speaking, exposure to feared physiological sensations (e.g., Wald & Taylor, 2008), accomplishment and a sense of mastery (e.g., Germain et al., 2004), behavioral activation (e.g., Jakupcak et al., 2006), and neurochemical changes leading to anxiolytic effects (e.g., Bossini et al., 2007) are strong possibilities given past literature linking such constructs to decline of PTSD severity.

4.1.4 Hypothesis 3: Were clinically significant gains made? Hypothesis 3 predicted that participants in the interoceptive prompts group, but not the cognitive distraction or exercise only groups, would have clinically significant reductions in PTSD symptoms after session six, and throughout the follow–up periods. Results demonstrated,

however, that participants in each group experienced clinically significant reductions in PTSD symptoms. In fact, although the differences between groups were minimal, the interoceptive prompts group consistently yielded less than or equal numbers of participants reporting clinically significant reductions in PTSD symptoms at each point after the six exercise sessions. This hypothesis was, therefore, rejected.

The rate of clinically significant gains made in terms of PTSD symptom reduction was impressive among the current sample. Indeed, among treatment completers, the rate of participants reporting clinically significant reductions in PCL–C scores was 73% or greater once the intervention was complete Using the rubric suggested by the National Center for PTSD (2007) wherein a reduction of 10 points on the PCL–C translates into clinically significant change, it is impressive that almost 90% of treatment completers met or exceeded this level from pre–treatment to post–treatment. This percentage of clinically significant gains persisted for the total sample of treatment completers from post–treatment to the one week follow–up. Furthermore, over half of total sample, all of which had met criteria for either full or subsyndromal PTSD, no longer met criteria for PTSD after the six exercise sessions. Given that there were minimal differences between groups in terms of clinically significant gains made over the course of the intervention, evidence further supports the hypothesis that common factors between groups were the anxiolytic agent of change at work in the current study. The impressive rate of clinically significant reductions in PTSD reported in the current sample also provides evidence that the reductions were not just statistical artefacts but, instead, translate into reduced distress and impairment in participants' lives.

4.1.5 Possible explanations and rule outs for gains made. The reductions in PTSD symptoms reported by the participants in the current study were impressive and beyond that which we would have expected with such a simple and brief intervention. These findings are particularly interesting because we provided no psychotherapeutic or psychopharmacological intervention; yet, in most cases, results met or exceeded changes for which we would expect during those types of interventions (Bisson et al., 2007; Seidler, & Wagner, 2006). In order to best conceptualize the possible reasons for the reductions in PTSD symptoms reported by participants, it may be helpful to discuss possible explanations and rule out factors above and beyond the intervention itself that may have influenced the results. Although none of these factors can be completely ruled out, explanation may serve to best conceptualize these arguments.

It may have been the case that there was an expectancy effect for each of the participants. More specifically, since participants were aware that the purpose of the study was to examine whether the intervention would reduce PTSD symptoms, they may have been primed to rate themselves as having lower PTSD symptoms as the study progressed. Although outcome expectancies may have influenced results, most treatment studies without some sort of deception would also suffer from this problem (e.g., Borkovec & Costello, 1993). Furthermore, it is less likely that the expectancy effect would carry on to the one–month follow–up, since most participants returned to their previous mostly sedentary lifestyles, effectively ceasing their treatment.

A related potential confound may be that participants were aware that their results were contributing to a research study and were motivated to rate themselves as having lower PTSD symptoms to appease the researchers involved. Again, as was the case with

the previous possibility, there is no reason to expect that the current study differed from most other treatment studies in this regard. Notwithstanding, steps were taken to reduce the impact that such influences may have on the final results. To begin, the primary researcher intentionally removed himself from the data collection during the study, leaving most or all contact to the research assistants. Contact during the exercise sessions by the certified personal trainers was standardized and efforts were made to make contact outside of the exercise interventions with the certified personal trainers as limited as possible. The contact that was made was focused mostly on scheduling and troubleshooting problems that arose (e.g., discomfort from the bicycle seat) and ensuring treatment adherence (e.g., declining requests to listen to music while exercising). Attempts by participants to appease researchers may have occurred in a minority of individuals; however, it is unlikely that this was a pervasive issue throughout our sample given that most of our study participants reported statistically and clinically significant reductions in PTSD symptoms and some reported experiencing an increase in symptom severity during the two week intervention.

Another possibility for the reductions in PTSD symptoms recognized among the current sample is that the participants recruited for the current study had less severe PTSD symptoms; alternatively, their symptoms may have been less stable, making it more likely that an intervention would have a greater effect. With regards to severity of symptoms, each participant met diagnostic criteria of either full or subsyndromal PTSD in a phone interview; furthermore, each participant had a PCL–C score that exceeded the established cut–score and the participant endorsed at least one re–experiencing, three avoidance/numbing, and two hyperarousal symptoms (in the case of subsyndromal PTSD

participants met criteria for two of three symptom clusters and scored over 35 in their PCL–C total score). Lastly, each participant reported in the phone screen that their PTSD symptoms were causing clinically significant distress and/or impairment in their lives. Given these inclusion criteria, it is unlikely that our study population was any less severe than other treatment studies utilizing community samples. With regards to the potential instability of PTSD symptoms in the current sample, the study design reduced the likelihood of this being a factor. Namely, three separate assessment points were conducted on each participant prior to their first exercise session: (1) an online screening questionnaire (PCL–C), (2) a phone–delivered structured clinical interview (SCID–II PTSD section and MINI screener), and (3) a final online screening questionnaire (PCL–C). The repeated assessment of pretreatment PTSD symptoms among each participant provided evidence to suggest that their PTSD symptoms were stable and not subject to abrupt changes without intervention.

Lastly, a possible explanation for the current findings is that the gains reported by participants were temporary in nature and would dissipate given more time. Supporting evidence for this claim may be that the present intervention did not address the indexed trauma nor did it directly address any of the obvious cognitive or behavioral sequelae resulting from PTSD. If these core therapeutic agents were not employed it seems unlikely that lasting gains could have been made. Unfortunately, we cannot definitely argue against this; however, given that gains were maintained at the one–month follow–up, evidence exists to the contrary. Furthermore, our findings suggest that the key therapeutic activities employed by traditional PTSD treatments (i.e., direct and prolonged exposure to trauma–related stimuli; Foa, Hembree, & Rothbaum, 2007) may not be

necessary to achieve therapeutic gains. Indeed, our intervention seemed to have brought about similar anxiolytic effects without this approach.

4.1.6 Hypothesis 4: Were trauma related memories elicited and reduced over time? Hypothesis 4 predicted that participants in the interoceptive prompts group, but not the cognitive distraction or exercise only groups, would demonstrate statistically significant drops in trauma–related memories brought on by the physical exercise. Findings indicated no statistically significant reduction in trauma–related memories which were engendered by the aerobic exercise intervention among the interoceptive prompts or any study group for that matter. This hypothesis was, therefore, rejected.

Counter to previous research (Wald & Taylor, 2008), the current intervention did not have the expected effect of engendering trauma–related memories among participants in the interoceptive prompts group. In fact, participants in each group rated the amount of trauma–related memories brought on by the aerobic exercise as being quite low throughout the duration of the study. Given that our intervention was unsuccessful in engendering trauma–related memories, it is unsurprising that increased attention to the physical sensations brought on by exercise did not bring about increased trauma–related memories. It may have been the case that the primary trauma of most participants did not involve significant peritraumatic hyperarousal and, thus, did not bring about trauma–related memories as expected. Alternatively, participants may have interpreted the question as being more literal (i.e., "How much *does riding a stationary bike* remind you of your index trauma"). It is possible that rewording of the question may have more clearly communicated our intended purpose.

These findings counter research which posits that directly addressing the primary trauma or related behaviors or cognitions bring about therapeutic change. Indeed, each of the evidence–based psychotherapies involves direct exposure to trauma–related cues (e.g., Prolonged Exposure, Foa et al., 2007) or addressing trauma–related cognitive distortions (e.g., Cognitive Processing Therapy; Resick, Monson, & Chard, 2010). Our intervention, on the other hand, did not involve any direct trauma exposure or cognitive restructuring and participants still reported gains. It may be the case that our intervention constituted a behavioral reconstruction; specifically, we may have implemented adaptive behaviors which did not directly address the primary trauma but nonetheless had a therapeutic effect by providing participants with an adaptive coping option for their PTSD symptoms (e.g., Jakupcak et al., 2006).

4.2 Secondary Findings

4.2.1 Motivation to enter into the study. The motivation to enter the study was high among the current sample. Indeed, the majority of participants rated themselves as having the highest motivation possible when asked on the initial online screen. This motivation was no different between groups. The high motivation to participate is likely a product of each participant wanting to receive a follow–up call to be entered into the study; even though a qualifier was added to the question to communicate that their level of motivation had no bearing on their ability to participate. These findings suggest that we either had a very motivated sample, or a sample that was eager to portray themselves as motivated in order to gain entry into the study (Pelletier, Uson, & Haddad, 1997).

4.2.2 Progression of exercise session response questions throughout treatment. Not only was the motivation high for participants in each group prior to entering the

study, but participants' motivation to continue with the intervention remained high throughout the duration of the study. Motivation was the only exercise response question to demonstrate a statistically significant change over the course of the six treatments; specifically, ratings of motivation to continue increased in a quadratic fashion. This is not surprising given the fact that the closer the participant got to the end of the study protocol, the more likely they would have been to want to finish. If a participant wanted to drop out, they would have likely done so early on, thus motivation ratings would be lowest at the start of the treatment. Also unlike other exercise response questions, motivation was significantly affected by group membership and a group and time interaction. The differences were minimal; however, findings indicated that the interoceptive prompts groups were reporting less increases in motivation as the study went on. This may have been because the task of the interoceptive prompts group was more uncomfortable than the other groups.

Difficulty of the physical exercise was reported by participants to be moderate throughout the study. As well, the difficulty of the exercise did not change significantly, nor did group membership have an effect on the ratings of difficulty. It may have been the case that the current study protocol was too easy for participants to complete and that they could have handled more intense physical exercise, although it is uncertain as to how that would have affected the primary outcome variables.

Like difficulty of the physical exercise, enjoyment was also not influenced by group membership or the interaction between group and time. It was likely the case that each participant appreciated the opportunity to participate–a comment that was echoed by most all participants who completed the study–regardless of what group they were

randomized too. Indeed, enjoyment was typically high throughout the study for each group.

Attention paid to physical sensations brought on by the exercise was relatively high throughout the study, and did not change. The effect of group membership and the interaction between group and time did not affect these ratings, suggesting that each group was receiving exposure to the physical sensations brought on by the exercise. The only difference was a visual trend wherein the cognitive distraction group consistently rated themselves as lower than the other two groups. This difference was intentional, given that the purpose of the cognitive distraction was to remove the attention paid to the physical activity; however, it did not bring about a marked distinction between the interoceptive prompts groups as we would have hoped. Differences in this question may have been more marked if we had provided a frame of reference. For example, if we had asked participants: "compared to the original fitness test on day 1, how much did you pay attention to the physical sensations brought on by the exercise?", participants may have answered much differently.

4.2.3 Success of the group task manipulation. We attempted to manipulate the intervention for two of the three groups. In the cognitive distraction group, the study protocol was developed such that focus would be taken away from the difficulty of the exercise and the attention paid towards the physiological effects of the exercise would reduce. In terms of the distraction, our metric for successful manipulation was the amount of distraction questions that the participants answered correctly. The rationale behind this was that if the participant answered the question correctly, they were paying attention to the video and not as much to the physiological effects of exercise. Participants in the

cognitive distraction group were found, on average, to answer the majority of the questions correctly. Furthermore, although the group ratings of attention paid to the physical sensations brought on by the physical exercise was not significantly lower than the other groups, there was a noticeable visual difference wherein participants in the cognitive distraction group rated themselves as not focusing on these as much as the other groups. Given a greater sample size these differences would likely have been significant. Concertedly, participants in the cognitive distraction group appeared to have been sufficiently distracted by the video.

On the other hand, in the interoceptive prompts group attempts were made to increase the attention paid to the physiological effects of the aerobic exercise. Although the ratings of focus paid to the physical sensations brought on by physical exercise were not significantly higher than those in the cognitive distraction group, there was a visual difference between the groups. Notwithstanding, the differences between the interoceptive prompts and exercise only groups were negligible. This may suggest that our attempts at distracting participants were more effective than increasing their attention paid to the physical exercise. Indeed, it appeared as if providing participants with interoceptive prompts did not increase the attention paid to the physical sensations more so than simply having participants exercise in silence. Given the difference between the cognitive distraction and interoceptive prompts group, we can deduce that our attempts to increase the participants' attention to the physical sensations brought on by exercise was at least partially successful.

The progression of the mean interoceptive prompt ratings across the six sessions is worthy of explanation. In both the upper and lower body interoceptive prompts, ratings

declined slightly over the course of the treatment; however, in the breathing interoceptive prompt, the average ratings rose. The distinction between the habituation to the difficulties in upper and lower body tension, opposed to breathing difficulties may suggest that participants were becoming more accustomed to the muscle strain associated with the physical exercise but not the aerobic requirements. Habituation of the difficulty in breathing may have been facilitated if we had provided participants with breathing training prior to beginning the sessions; however, in an effort to standardize and limit contact with researchers this was not done. In terms of potential effect on the primary results, given that the most affected PTSD symptom was hyperarousal and the most affected AS dimension was AS physical, our findings may have been amplified had participants been given more information on how to best deal with the physiological effects of exercise without distracting themselves from them.

4.2.4 Attrition and retention. Our study was typical in terms of attrition when compared to other studies in the same avenue of research. Indeed, most studies assessing the anxiolytic potential of aerobic exercise report approximately 25% attrition during the course of the study (e.g., Broman–Fulk et al., 2008). Since follow–up measures are uncommon in this avenue of research, it is difficult to compare our retention of participants throughout the follow–up periods to that of other studies. Notwithstanding, when compared to other treatment studies for PTSD utilizing other therapeutic interventions (e.g., prolonged exposure and cognitive restructuring, 37% dropouts; Foa, Haslam, Williams, & Creamer, 2005), our retention during the intervention phase of the study was good. Concertedly, our findings suggest that our intervention was no less acceptable than other PTSD interventions.

4.2.5 Psychopathology in the current sample. We included participants with both full and subsyndromal PTSD in the current sample. Although each participant was required to endorse clinically significant distress and/or impairment resulting from their PTSD symptoms, the prevalence of full versus subsyndromal PTSD speaks to the symptom profile and the severity of the current sample. As was noted in the results, we had more participants reporting full PTSD symptoms compared to subsyndromal PTSD. Further, even in the instances where subsyndromal PTSD was endorsed, PTSD symptoms were reported as the primary disorders. Taken in concert with the severity of PTSD ratings on the PCL–C at the initial online screening and pre–treatment screen, we considered our sample to have similar PTSD severity as treatment seeking samples (e.g., Lang, Laffaye, Satz, Dresslhaus, & Stein, 2003).

Comorbidities in the current sample were common; in fact, only one participant reported no additional comorbidities beyond PTSD. The majority of participants were reporting four or five additional disorders in addition to their posttraumatic stress; however, each of these was secondary to PTSD. The most commonly endorsed disorder in the current study was depression, followed closely by social anxiety. Such disorders, especially depression (Beck, DeMond, & Palyo, 2009), are commonly seen in PTSD samples (Hofmann, Litz, & Weathers, 2003; Collimore et al., 2010). With regards to depression, our sample reported entering the study with an average rating suggestive of severe depression. Given that PTSD was rated as primary, we expect that participants' depression was caused by the impact that PTSD was having on their lives. These results lend evidence to the generalizability of our results to other PTSD samples.

4.2.6 Physical fitness prior to entering the current study. As a group, our sample was not physically active and did not fare well on the fitness test. The most commonly endorsed self–reported physical fitness level was *average*; four individuals rated their physical fitness at the lowest level (very poor). The majority of our sample reported that they engaged in vigorous activity for at least 30 minutes per day less than once per week; however, given that the North American guidelines suggest a minimum of 150 minutes of moderate to vigorous physical activity every week in order to obtain substantial health benefits (Pubic Health Agency of Canada, 2012), the majority of our sample were likely falling short of this requirement.

In–lab testing during the current study revealed notable differences between participants' self–reported measures of physical fitness and aerobic fitness level. In particular, the Canadian Physical Activity Fitness and Lifestyle Approach Health Benefit zone for nearly half of the participants was at the lowest level (i.e., needs improvement) and only seven out of 33 fell within the good (n = 4), very good (n = 2) or excellent (n = 1) ranges. Overestimation of physical fitness is not uncommon in the general population; notwithstanding, the question remains as to whether or not the overestimation witnessed in the current study differs significantly from that in the general population. Much correlational research has been published on the association between anxiety disorder diagnoses and self–perceived physical activity engagement (e.g., De Moor, Beem, Stubbe, Boomsma, & de Geus, 2006; De Moor, Boomsma, Stubbe, Willemsen, & de Geus, 2008; Moshier et al., 2009); however, no studies have confirmed the validity of such research approaches.

We found no significant differences in self–reported physical activity engagement once the study was completed. This was surprising given the impressive reduction in PTSD symptoms over the course of the treatment. Not surprising however, we recognized an increase in PTSD symptoms after the intervention was over. Our data suggested that once the intervention had ended, participants reverted back to their original physical fitness habits, and their PTSD symptoms began to return, albeit at a significantly reduced level as compared to their original screen scores. The lack of adherence to physical activity once the study had ended was predictable in retrospect given that we provided no counselling as to how to best go about implementing more active lifestyles; instead, we offered free gym membership passes and discounts to local gym facilities–which none of our participants took advantage of.

4.3 Limitations

The current study had several limitations which should be considered when interpreting the results and that may provide direction for future research. First, a follow–up clinical interview would have provided further confirmation of clinically significant gains reported on the PCL–C during the follow–up periods. Although previous research utilizing the PCL–C suggests these gains are indicative of actual clinical gain (for review see National Center for PTSD, 2007), a structured clinical interview would have added more weight to this assumption. Second, we only used one of the many exercise forms that have been studied with regards to anxiolytic potential (e.g., yoga, Field, Diego, & Hernandex–Reif, 2010; strength training, Bibeau et al., 2010). As such, we are uncertain if the results in our study would be replicated if another form of exercise was substituted. Third, our study screened out individuals with chronic pain or physical health conditions

that would make physical exercise potentially unsafe. Given that PTSD is often comorbid with chronic pain conditions (e.g., Asmundson & Katz, 2009), we are unsure if our findings would generalize to this rather large subset of individuals affected by PTSD. In the same vein, individuals with substance abuse problems were screened out for safety reasons. Given that substance use–particularly alcohol–related disorders (Breslau, Davis, Andreski, & Peterson, 1991; Brown, Vik, Patterson, & Grant, 1995)–is common among individuals with PTSD, we are uncertain if our findings would generalize to this group. Fourth, our study did not include an inactive control group (i.e., a group of participants who did not participate in physical activity). Although stability of PTSD symptoms were established and the study indicated a significant change over the course of the intervention, the lack of control group precludes us from concluding that these gains would not have occurred spontaneously. Future studies should consider including a control group who participates in the same way as intervention groups minus the active intervention component. Lastly, our protocol was relatively short. Given the brevity of our intervention we cannot comment on a dose response relationship between aerobic exercise and therapeutic gains made. Future studies may wish to manipulate the length of the intervention to investigate this limitation further.

4.4 Future Directions

A number of future research directions can be taken from the findings in the current study. To begin, the use of an inactive control group whereby participants do not participate in any type of exercise intervention, to compare against an active intervention group participating in exercise, may provide information about the independent anxiolytic effects of such an intervention. Often participants in such a condition are either

placed in a waitlist control (Smits et al., 2008) in order to maximize treatment fidelity. Alternatively, additional exercise interventions (e.g., stretching, yoga, resistance training) may be beneficial to compare against aerobic exercise in order to discern whether or not the anxiolytic mechanisms demonstrated in the current study are owned only by aerobic exercise.

Secondly, investigating the potential mediating role of extraneous variables may serve to shed further light on the anxiolytic mechanisms and processes involved in aerobic exercise. Indeed, it may have been the case in the current study that AS, or perhaps some other variable not examined (e.g., a sense of mastery), was playing a role in the reduction in PTSD symptoms. Future research may benefit from examining the interactions between such risk and resiliency factors, disorder symptoms, and their response to aerobic exercise interventions. Elucidating the interaction between such variables may serve to guide development of future exercise interventions to directly target the most worthwhile variables to increase mental well–being.

Third, given that our study was relatively brief and each participant engaged in the same amount of exercise at the same intensity, it may be advantageous to explore the dose–response relationship between aerobic exercise and reductions in disorder symptoms. For example, it may have been the case that our participants' PTSD symptoms would have been more stable at the month follow–up if they had engaged in more sessions over a longer period of time. Examinations of such may be able to provide clinicians with a prescribed intensity and amount for which to recommend to participants who are deemed appropriate for such interventions by qualified physical health and medical professionals.

Fourth, given that our intervention was found to significantly reduce PTSD symptoms, but that the symptoms tended to return throughout the follow–up periods and that participants typically reverted back to their previously sedentary lifestyles, it may be advantageous to examine the effects of booster sessions. Alternatively, counseling sessions with physical health professionals may be provided to participants at the end of the in–lab intervention in order to provide them with the necessary information and resources to continue to engage in healthy and safe physical activity. Indeed, the effectiveness of the intervention should not only be measured by it's ability to reduce symptoms, but to also maintain gains; therefore, finding ways to maximize adherence to healthy physical lifestyles among those affected by PTSD is paramount.

Lastly, although we provided evidence that aerobic exercise is effective in reducing PTSD symptoms in the current investigation, we did not compare this intervention to traditional interventions for PTSD. Essentially, the comparison between aerobic exercise and first–line therapeutic approaches to treating PTSD (i.e., cognitive behavioral therapy, eye–movement desensitization, pharmacotherapy; Taylor, 2004) would provide clinicians with a gauge to examine whether or not aerobic exercise is a truly worthwhile therapeutic endeavour. Such studies are a necessary second–step in this line of research.

4.5 Clinical and Theoretical Implications

PTSD impairs both social and occupational functioning, engenders other significant mental health issues (e.g., depression), diminishes physical health, and increases suicidality (APA, 2000; Asmundson et al., 2002; Fetzner et al., 2012; Sareen et al., 2005, 2007; Taylor, 2006); as such, it is now considered a public health concern. Evidence–based treatments are available, with exposure–based therapies and SSRI

medication identified as first–line interventions (Ballenger et al., 2000; Taylor, 2006); however, those with PTSD and other anxiety disorders are often faced with numerous barriers to treatment, including lack of available, preferred, or accessible services (Sareen et al., 2007). Consequently, investigation and identification of cost efficient, widely accessible, and evidence–based stand–alone or adjunctive interventions for PTSD and the other anxiety disorders is warranted; such interventions may prove to be of considerable individual and societal benefit. The current research suggests that regular aerobic exercise may represent such a treatment.

Our goal for the study was not just to ascertain evidence for the potential utility of reducing PTSD symptoms, but also to investigate the anxiolytic mechanisms involved in that change. Unfortunately, the current study did not offer any solid leads in this regard. What the current data does suggest is that aerobic exercise works to reduce PTSD symptoms. Further, our research suggests that methods which aim to reduce the potentially threatening nature of physical exercise may also work to increase mental health benefits.

The reduction of PTSD symptoms by the aerobic intervention employed in the current study also speaks to the fact that therapeutic benefits, with regards to PTSD treatment, may be gained through activities which do not directly address the primary trauma. Such postulations are made cautiously as therapeutic processing and exposure to trauma–related memories and cues are the hallmark of empirically–based therapies. Indeed, lasting treatment effects may be reinforced through directly addressing trauma–related memories and cognitions; however, aerobic exercise may provide an additional tool for clinicians to employ prior to traditional exposure–based therapies in order to

decrease physiological arousal during such activities. Employing aerobic exercise regimens as adjuncts to traditional PTSD therapy may have the added benefit of encouraging healthy lifestyles, increasing a sense of mastery among clients, encouraging adaptive coping strategies, along with a host of other potential benefits that come along with aerobic exercise engagement.

The current study may be best viewed as providing evidence that aerobic exercise holds considerable potential for reducing PTSD symptoms; but, more research is needed. Indeed, addressing the aforementioned limitations and directions for future research may shed further light on the potential for aerobic exercise to act as either an adjunct to traditional psychotherapies or psychopharmacological therapies, or even a standalone intervention for those who meet appropriate criteria.

5.0 References

Abrantes,A. M., Strong, D. R., Cohn, A., Cameron, A. Y., Greenberg, B. D., Mancebo, M. C., & Brown, R. A. (2009). Acute changes in obsessions and compulsions following moderate–intensity aerobic exercise among patients with obsessive–compulsive disorder. *Journal of Anxiety Disorders, 23*, 923–927. doi:10.1016/j.janxdis.2009.06.008

Adkins, J. W., Weathers, F. W., McDevitt–Murphy, M., & Daniels, J. B. (2008). Psychometric properties of seven self–reported measures of posttraumatic stress disorder in college students with mixed civilian trauma exposure. Journal of Anxiety Disorders, 22, 1393–1402. doi:10.1016/j.janxdis.2008.02.002

Afifi, T.O., Asmundson, G.J.G., & Sareen, J. (2009). Epidemiology of traumatic events and post–traumatic stress disorder. In D.J. Nutt, M.B. Stein, & J. Zohar (Eds.), *Post–Traumatic Stress Disorder, Second Edition* (pp. 14–22). New York, NY: Informa Healthcare, Inc.

American Psychiatric Association. (1952). *Diagnostic and statistical manual of mental disorders*. Washington, DC: Author.

American Psychiatric Association. (1968). *Diagnostic and statistical manual of mental disorders (2nd ed.)*. Washington, DC: Author.

American Psychiatric Association. (1980). *Diagnostic and statistical manual of mental disorders (3rd ed.)*. Washington, DC: Author

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders (4th ed.).* Washington, DC: Author.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.).* Washington, DC: Author.

Andrykowski, M. A., Cordova, M. J., Studts, J. L., & Miller, T. W. (1998). Posttraumatic stress disorder after treatment for breast cancer: Prevalence of diagnosis and use of the PTSD checklist–civilian version (PCL–C) as a screening instrument. *Journal of Consulting Clinical Psychology, 66*, 586–590. doi: 10.1037/0022–006X.66.3.586

Arntz, A. (2002). Cognitive therapy versus interoceptive exposure as treatment of panic disorder without agoraphobia. *Behaviour Research and Therapy, 40*, 325–341. doi:10.1016/S0005–7967(01)00014–6

Asmundson, G. J. G., Abrams, M., Collimore, K. (2008). Pain and anxiety disorders. In Szolensky, M., & Smits, J. (2008). *Anxiety in health behaviours and physical illness. Series in anxiety relations disorders* (pp 207–235). New York, NY, US: Springer Science and Business Media. Xi, 379.

Asmundson, G. J. G., Fetzner, M. G., DeBoer, L. B., Powers, M. B., Otto, M. W., & Smits, J. A. J. (2013). Let's get physical: A contemporary review of the anxiolytic effects of exercise for anxiety and its disorders. *Depression and Anxiety, 30*, 362–373. doi: 10.1002/da.22043

Asmundson, G. J. G., Frombach, I., McQuaid, J., Pedrelli, P., Lenox, R., & Stein, M. B. (2000). Dimensionality of posttraumatic stress symptoms: A confirmatory factor analysis of DSM–IV symptom clusters and other symptom models. *Behaviour Research and Therapy*, *38*, 203–214. doi: 10.1016/S0005–7967(99)00061–3

Asmundson, G. J. G., & Katz, J. (2009). Understanding the co–occurrence of anxiety disorders and chronic pain: State–of–the–art. *Depression and Anxiety, 26*, 888–901. doi: 10.1002/da.20600

Asmundson, J. G., Norton, G. R., Allerdings, M. D., Norton, P. J., & Larson, D. K. (1998). Posttraumatic stress disorder and work–related injury. *Journal of Anxiety Disorders, 12*, 57–69. doi:10.1016/S0887–6185(97)00049–2

Asmundson, G. J. G., & Stapleton, J. (2008). Associations between dimensions of anxiety sensitivity and PTSD symptom clusters in active–duty police officers. *Cognitive Behaviour Therapy*, *37*, 66–75. doi:10.1080/16506070801969005

Asmundson, G. J. G., Stapleton, J. A., & Taylor, S. (2004). Are avoidance and numbing distinct PTSD symptom clusters? *Journal of Traumatic Stress, 17*, 467–475. doi: 10.1007/s10960–004–5795–7

Asmundson, G. J. G., Stein, M., & McCreary, D. (2002). Posttraumatic stress disorder symptoms influence health status of deployed peacekeepers and nondeployed military personnel. *The Journal of Nervous and Mental Disease, 190*(12), 807–815.

Asmundson, G. J. G., Weeks, J. W., Carlton, R. N., Thibodeau, M. A., & Fetzner, M. G. (2011). Revisiting the latent structure of the anxiety sensitivity construct: More evidence of dimensionality. *Journal of Anxiety Disorders, 25*, 138–147. doi:10.1016/j.janxdis.2010.08.013

Bahrke, M. S., & Morgan, W. P. (1978). Anxiety reduction following exercise and meditation. *Cognitive Therapy and Research. 2*, 323–333. doi: 10.1007/BF01172650

Ballenger, J. C., Davidson, J. R., Lecrubier, Y., Nutt, D. J., Foa, E. B., Kessler, R. C., McFarlane, A. C., Shalev, A. Y. (2000). Consensus statement on posttraumatic stress disorder from the International Consensus Group on Depression and Anxiety. *Journal of Clinical Psychiatry. 61*(suppl 5):60–66.

Barlow, D. H., Gorman, J. M., Shear, M. K., & Woods, S. W. (2000). Cognitive–behavioral therapy, imipramine, or their combination for panic disorder: A randomized controlled trial. *Journal of the American Medical Association, 283*, 2529–2536. doi: 10.1001

Beck, J., DeMond, G., Clapp, J., & Palyo, S. (2009). Understanding the interpersonal impact of trauma: Contributions of PTSD and depression. *Journal of Anxiety Disorders*, *23*, 443–450. doi: 10.1016/j.janxdis.2008.09.001

Beck, J. G., Shipherd, J. C., & Zebb, B. J. (1997). How does interoceptive exposure for panic disorder work? An uncontrolled case study. *Journal of Anxiety Disorders, 11*, 541–556. doi:10.1016/S0887–6185(97)00030–3

Beekley, M. D., Brechue, W. F., Dehoyos, D. V., Garzarella, L., Werber–Zion, G., & Polluck, M. L. (2004). Cross–validation of the YMCA submaximal cycle ergometer test to predict VO2 max. Research Quarterly for Exercise and Sport, 75, 337–342. doi:10.1080/02701367.2004.10609165

Beck, J. G., & Steer, R. A. (1993). *Beck scale for suicide ideation: Manual*. San Antonio, TX: Psychological Corporation.

Bernstein, A., Leen–Feldner, E. W., Kotov, R., Schmidt, N.B., & Zvolensky, M. J. (2006). A test of a panic–relevant diathesis–stress model using a taxonic index of anxiety sensitivity. In: A. J. Sanfelippo (Editor). *Panic disorders: New research*. Nova Science Publishing, Hauppauge, NY, pp 15–40.

Bernstein, A., Zvolensky, M. J., Norton, P. J., Schmidt, N. B., Taylor, S., & Forsyth, J. P., et al. (2007). Taxometric and factor analytic models of anxiety sensitivity:

Integrating approaches to latent structural research. *Psychological Assessment, 19*, 74–87. doi: 10.1037/1040–3590.19.1.74

Bibeau, W. S., Moore, J. B., Mitchell, N. G., Vargas–Tonsing, T., & Bartholomew, J. B. (2010). Effects of Acute Resistance Training of Different Intensities and Rest Periods on Anxiety and Affect. *Journal of Strength and Conditioning Research. 24*, 2184–2191. doi: 10.1519/JSC.0b013e3181ae794b

Bisson, J. I., Ehlers, A., Matthews, R., Pilling, S. Richards, D., & Turner, S. (2007). Psychological treatments for chronic post–traumatic stress disorder: Systematic review and meta–analysis. *The British Journal of Psychiatry, 190*, 97–104 doi:10.1192/bjp.bp.106.021402

Blanchard, E. B., Jones–Alexander, J., Buckley, T. C., & Forneris, C. A. (1996). Psychometric properties of the PTSD Checklist (PCL). *Behaviour Research and Therapy, 34*, 669–673. doi:10.1016/0005–7967(96)00033–2

Blumenthal, J. A., Babyak, M. A., Dorasiwamy, P. M., Watkins, L., Hoffman, B. M., Barbour, K. A., … Sherwood, A. (2007). Exercise and pharmacotherapy in the treatment of major depressive disorder. Psychosomatic medicine, 67, 587–596. doi: 10.1097/PSY.0b013e318148c19a

Blechert, J., Wilhelm, F. H., Meuret, A. E., Wilhelm, E. M., Wilhelm, E. M., & Roth, W. T. (2010). Respiratory, autonomic, and experimental responses to repeated inhalations of 20% CO2 enriched air in panic disorder, social phobia, and healthy controls. *Biological Psychology, 84*, 104–111. doi:10.1016/j.biopsycho.2010.01.002

Bossini, L., Tavanti, M., Lombardelli, A., Calossi, S., Polizzotto, N. R., Galli, R., Vatti, G., Pieraccini, F., & Castrogiovanni, P. (2007). Changes in hippocampal volume in patients with post–traumatic stress disorder after sertraline treatment. *Journal of Clinical Psychopharmacology, 27*, 233–235. doi: 10.1097/01.jcp.0000264979.09862.a8

Borkovec, T.D., & Costello, E. (1993). *Efficacy of applied relaxation and cognitive–behavioral therapy in the treatment of generalized anxiety disorder. Journal of Consulting and Clinical Psychology, 61*(4), 611–619.

Breslau, N., Davis, G. C.., Andreski, P., & Peterson, E. (1991). Traumatic events and posttramatic stress disorder in an urban population of young adults. *Archives of General Psychiatry, 48*, 216–222. doi:10.1001/archpsyc.1991.01810270028003

Breslau, N., Davis, G. C., Andreski, P., Peterson, E. L., Schultz, L. R. (2002). Sex differences in posttrauamtic stress disorder. *Archives of General Psychiatry, 54* (11), 1044–32.

Broman–Fulks, J. J., Berman, M. E., Rabian, B., & Webster, M. J. (2004). Effects of aerobic exercise on anxiety sensitivity. *Behaviour Research and Therapy, 42*, 125–136. doi:10.1016/S0005–7967(03)00103–7

Broman–Fulks, J. J., Green, B. A., Berman, M. E., Olatunji, B. O., Arnau, R. C., Deacon, B. J., et al. (2008). The latent structure of anxiety sensitivity – revisited. *Assessment, 15*, 188–203. doi: 10.1177/1073191107311284

Broman–Fulks, J. J., Deacon, B. J., Olatunji, B. O., Bondy, C. L., Abramoqitz, J. S., & Tolin, D. F. (2010). Categorical or dimensional: A reanalysis of the anxiety sensitivity construct. *Behavior Therapy, 41*, 154–171.

Broman–Fulks, J. J., & Storey, K. M. (2008). Evaluation of a brief aerobic exercise intervention for high anxiety sensitivity. *Anxiety, Stress & Coping, 21*, 117–128. DOI:10.1080/10615800701762675

Bromet, E., Sonnega, A., & Kessler, R. C. (1998). Risk factors for DSM–III–R posttraumatic stress disorder: Findings from the National Comorbidity Survey. *American Journal of Epidemiology, 147*, 353–361.

Brown, C., Dunbar–Jacob, J., Palenchar, D. R., Kelleher, K. J., Bruehlman, R. D., Sereika, S., Thase, M. E. (2001). Primary care patient's personal illness models for depression: A preliminary investigation. *Family Practice, 18*,314–320. doi: 10.1093/fampra/18.3.314

Brown, S. A., Vik, P. W., Patterson, T. L., Grant, I., & Schuckit, M. A. (1995). Stress, vulnerability and adult alcohol relapse. *Journal of Studies on Alcohol and Drugs, 56*(5), 538–545.

Broocks, A., Bandelow, B., Pekrun, G., George, A., Meyer, T., Bartmann, U., Hillmer–Vogel, U., & Ruther, E. (1998). Comparison of aerobic exercise, clomipramine, and placebo in the treatment of panic disorder. *American Journal of Psychiatry, 115*(5), 603–609.

Buffart, L. M., van den Berg–Emons, R. J. G., can Wijlen–Hempel, M. S., Stam, H. J., & Roebroeck, M. E. (2008). Health–related physical fitness of adolescents and young adults with myelomeningocele. *European Journal of Physiology, 103*, doi: 10.1007/s00421–008–0684–z

Carleton, R. N., Brundin, P., Asmundson, G. J. G., & Taylor, S. (2006). *Traumatic life events questionnaire.* Unpublished manuscript, Department of Psychology, University of Regina, Regina, Canada.

Chaouloff, F. (1997). Effects of acute physical exercise on central serotonergic systems. *Medical Science Sports Exercise, 29,* 58–62. doi:10.1016/j.beth.2009.02.005

Clark, D. M. (1986). A cognitive approach to panic. *Behaviour Research and Therapy, 24*, 461–470. doi:10.1016/0005–7967(86)90011–2

Clark, M. S., Milberg, S., & Ross, J. (1983). Arousal cues arousal–related material in memory: Implications for understanding effects of mood on memory. *Journal of Verbal Learning and Verbal Behavior, 22*, 633–649.

Chisholm, D., Collis, M., Kulak, L., Davenport, & Gruber, (1975). Physical activity readiness. *British Columbia Medical Journal, 17*, 375–378.

Chmelo, E. A., Hall, E. E., Miller, P. C., & Sanders, K. N. (2009). Mirrors and resistance exercise, do they influence affective responses? *Journal of Health Psychology, 14*, 1067–1074. doi: 10.1177/1359105309342300

Cohen, B. E., Gima, K., Bertenthal, D., Kim, S., Marmar, C. R., & Seal, K. H. (2009). Mental health diagnoses and utilization of VA non–mental health medical services among returning Iraq and Afghanistan veterans. *Journal of General Internal Medicine, 25*, 18–24. doi: 10.1007/s11606–009–1117–3

Collimore, K. C., Asmundson, G. J. G., Taylor, S., & Jang, K. L. (2009). Socially related fears following exposure to trauma: Environmental and genetic influences. *Journal of Anxiety Disorders, 23*, 240–246. doi:10.1016/j.janxdis.2008.07.006

Collimore, K. C., Carleton, R. A., Hoffman, S. G., & Asmundson, G. J. G. (2010). Posttraumatic stress and social anxiety: The interaction of traumatic events and interpersonal fears. *Depression and Anxiety, 27*, 1017–1026. doi: 10.1002/da.20728

Collimore, C., McCabe, R., Carleton, N., & Asmundson, G. (2008). Media exposure and dimensions of anxiety sensitivity: Differential associations with PTSD symptom clusters. *Journal of Anxiety Disorders*, *22*, 1021–1028. doi:10.1016/j.janxdis.2007.11.002

Cotman, C. W., & Engesser–Cesar, C. (2002). Exercise enhances and protects brain function. *Exercise and Sport Sciences Reviews, 30*(2), 75–79.

Craft, L. L. (2005). Exercise and clinical depression: Examining two psychological mechanisms. *Psychology of Sport and Exercise, 6,* 151–171. doi:10.1016/j.psychsport.2003.11.003

Craske, M. G., Rowe, M., Lewin, M., & Noriega–Dimitri, R. (1997). Interoceptive exposure versus breathing retraining within cognitive–behavioral therapy for panic disorder with agoraphobia. *British Journal of Clinical Psychology, 36*, 85–99. doi: 10.1111/j.2044–8260.1997.tb01233.x

Creamer, M., Burgess, P., & Mcfarlane, A. C. (2001). Post–traumatic stress disorder: Findings from the Austrailian National Survey of Mental Health and Well–being. *Psychological Medicine, 31*(7), 1237–1247.

Creamer, M., Burgess, P., & Pattison, P. (1992). Reaction to trauma: A cognitive processing model. *Journal of Abnormal Psychology, 101*, 454–459. doi: 10.1037/0021

de Meirleir, K., Naaktgeboren, N., Van Steireghem, A., Gorus, F., Olbrecht, J., & Block, P. (1986). Beta–endorphin and ACTH levels in peripheral blood during and after aerobic and anaerobic exercise. *European Journal of Applied Physiology, 55*, 5–8. doi: 10.1007/BF00422884

De Moor, M. H. M., Beem, A. L., Stubbe, J. H., Boomsma, D. I., & De Geus, E. J. C. (2006). Regular exercise, anxiety, depression and personality: A population–based study. *Preventative Medicine, 42*, 273–279. doi:10.1016/j.ypmed.2005.12.002

De Moor, M. H. M., Boomsma, D. I., Stubbe, J. H., Willemsen, G., & de Geus, E. J. (2006). Testing causality in the association between regular exercise and symptoms of anxiety and depression. *Archives of General Psychiatry, 65*(8), 897–905.

Devins, G., Orme, C. (1985). Centre for epidemiological studies depression scale. In *Test Critiques. 2*, KeyserD, SweetlandR (eds). Test Corporation of America: Kansas City, MO; 144–160.

Diaz, A. B. & Motta, R. (2008). The effects of an aerobic exercise program on posttraumatic stress disorder severity in adolescents. *International Journal of Mental Health, 10*(1), 49–59.

Dimidjian, S. Martell, C. R., Addis, M. E. & Herman–Dunn, R. (2008). *Behavioral activation for depression. In Barlow, D. H (Ed.) Clinical handbook of psychological disorders: A step–by–step treatment manual (4th edition)*. Guilford Press: New York.

Dishman, R. K. (1994). The measurement conundrum in exercise adherence research. *Medicine and Science in Sports and exercise, 26*, 1382–1390. doi: 10.1249/00005768–199411000–00013

Dunn, A. L., Trivedi, M. H., Kampert, J. B., Clark, C. G., & Chambliss, H. O. (2005). Exercise treatment for depression: Efficacy and dose response. *American Journal of Preventive Medicine*, *28*, 1–8. doi:10.1016/j.amepre.2004.09.003

Duvigneaud, N., Matton, L., Wijndaele, K., Deriemaeker, P., Lefevre, J., Philippaerts, R., Thomis, M., Delecluse, C., & Duquet, W. (2008). Relationship of obesity with physical activity, aerobic fitness and muscle strength in Flemish adults. *The Journal of Sports Medicine and Physical Fitness, 48*(2), 201–210.

Dohrenwend, B. P., Turner, J. B., Turse, N. A., Adams, B. G., Koenen, K. C., & Marshall, R. (2006). The psychological risks of Vietnam for U.S. veterans: A revisit with new data and methods. *Science, 313*, 979–982. doi: 10.1126/science.1128944

Ehlers, A., & Clark, D. M. (2000). A cognitive model of posttraumatic stress disorder. *Behavior Research and Therapy, 38*, 319–345. doi:10.1016/S0005–7967(99)00123–0

Ekkekakis, P., & Petruzzello, S. J. (1999). Acute aerobic exercise and affect: Current status, problems and prospects regarding dose–response. Sports Medicine, 28, 337–374.

Esquivel, G., Diaz–Galvis, J., Schruers, K., Berlanga, C., Lara–Munoz, C., & Griez, E. (2008). Acute exercise reduces the effects of 35% CO_2 challenge in patients with panic disorder. *Journal of Affective Disorders, 107,* 217–220. doi:10.1016/j.jad.2007.07.022

Evans, S., Ferrando, S., Findler, M., Stowell, C., Smart, C., & Haglin, D. (2008). Mindfulness–based cognitive therapy for generalized anxiety disorder. *Journal of Anxiety Disorders, 22*, 716–721. doi:10.1016/j.janxdis.2007.07.005

Falsetti, S. A., Resnick, H. S., Resick, P. A., & Kilpatrick, D. G. (1993). The Modified PTSD Symptom Scale: a brief self–report measure of posttraumatic stress disorder. *Behavior Therapist, 16*, 161–162

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.–G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*, 1149–1160. doi:10.3758/BRM.41.4.1149

Feeny, N. C., Zoellner, L. A., Fitzgibbons, L. A., & Foa, E. B. (2000). Exploring the roles of emotional numbing, depression, and dissociation in PTSD. *Journal of Traumatic Stress, 13*, 489–498. doi: 10.1023/A:1007789409330

Field, T., Diego, M., & Hernandex–Reif, M. (2010). Tai chi/yoga effects on anxiety, heartrate, EEG, and math computations. *Complementary Therapies in Clinical Practice, 16*, 235–238. doi: 10.1016/j.ctcp.2010.05.014,

Feldner, M., Lewis, S., Leen–Feldner, E., Schnurr, P., & Zvolensky, M. (2006). Anxiety sensitivity as a moderator of the relation between trauma exposure frequency and posttraumatic stress symptomatology. *Journal of Cognitive Psychotherapy*, *20*, 201–213. doi: http://dx.doi.org/10.1891/088983906780639808

Fetzner, M. G., Collimore, K. C., Carleton, R. N., & Asmundson, G. J. G. (2011). Clarifying the relationship between AS dimensions and PTSD symptom clusters: Are negative and positive affectivity theoretically relevant constructs? *Cognitive Behaviour Therapy, 41*, doi:10.1080/16506073.2011.621971

Fetzner, M. G., Horswill, S. C., Boelen, P., & Carleton, R. N. (in press). Intolerance of uncertainty and PTSD: Exploring the construct relationship in a community sample with a heterogeneous trauma history. *Cognitive Therapy and Research.*

Fetzner, M. G., MacMillan, K. A., Sareen, J., & Asmundson, G. J. G. (2011). What is the association between traumatic life events and alcohol abuse/dependence in people with and without PTSD? Findings from a nationally representative sample. *Depression and Anxiety, 28*, 632–638. doi: 10.1002/da.20852

First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. W. (2000). *Structured clinical interview for DSM–IV Axis I disorders administration booklet – Clinical version.* American Psychiatric Publishing: Arlington, VA.

Flannery, D. J., Singer, M. I., & Wester, K. (2001). Violence exposure, psychological trauma, and suicide risk in a community sample of dangerously violent adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*, 435–442. doi: 10.1097/00004583–200104000–00012

Foa, E., Hembree, E., & Rothbaum, E. O. (2007). *Prolonged exposure therapy for PTSD: Emotional processing of traumatic experiences. Therapist guide.* Oxford University Press: New York.

Foa, E. B., & Kozak, M. J. (1986). Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin, 99*, 20–35. doi: 10.1037/0033–2909.99.1.20

Foa, E. B., Steketee, G., & Rothbaum, B. O. (1989). Behavioral/cognitive conceptualizations of post–traumatic stress disorder. *Behavior Therapy, 20*, 155–176. doi: 10.1016/S0005–7894(89)80067–X

Foa, E. B., & Rothbaum, B. O. (1998). *Treating the trauma of rape*. New York. Guilford Press.

Forbes, D., Haslam, N., Williams, B. J., & Creamer, M. (2005). Testing the latent structure of posttraumatic stress disorder: A taxometric study of combat veterans. *Journal of Traumatic Stress, 18*, 647–656. doi: 10.1002/jts.20073

Frazier, P., Conlon, A., Glaser, T. (2001). Positive and negative life changes following sexual assault. *Journal of Consulting and Clinical Psychology, 69*, 1048–1055. doi: 10.1037/0022–006X.69.6.1048

Frueh, B. C., Turner, S. M., Beidel, D. C., Mirabella, R. F., Jones, W. J. (1996). Trauma management therapy: a preliminary evaluation of a multicomponent behavioral treatment for chronic combat–related PTSD. *Behavior Research & Therapy, 34*, 533–543. doi: 10.1016/0005–7967(96)00020–4

Germain, A., Krakow, B., Faucher, B., Zadra, A., Nielson, T., Hollifield, M., Warner, W., & Koss, M. (2004). Increased mastery elements associated with imagery rehearsal treatment for nightmares in sexual assault survivors with PTSD. *Dreaming, 14*, 195–206. doi: 10.1037/1053–0797.14.4.195

Gledhill, N. (2004). *The Canadian Physical Activity, Fitness & Lifestyle Approach, Third Edition.* Ottawa, ON: Canadian Society for Exercise Physiology.

Goldberg, J., Eisen, S. A., True, W. R., & Henderson, W. G. (1990). A twin study of the effects of the Vietnam conflict on alcohol drinking patterns. *American Journal of Public Health, 80*, 570–574. doi: 10.2105/AJPH.80.5.570

Goldstein, A. J., & Chambless, D. L. (1978). A reanalysis of agoraphobia. *Behavior Therapy, 9,* 47–59. doi:10.1016/S0005–7894(78)80053–7

Goodwin, R. D. (2003). Association between physical activity and mental disorders among adults in the United States. *Preventive Medicine*, *36*, 698–703. doi:10.1016/S0091–7435(03)00042–2

Greenberg, P. E., Sisitsky, T., Kessler, R. C., Finkelstein, S. N., Berndt, E. R., Davidson, J. R. T., Ballenger, J. C., & Fyer, A. J. (1999). The economic burden of anxiety disorders in the 1990s. *Journal of Clinical Psychiatry, 60,* 427–435.

Gum, A. M., King–Kallimanis, B., & Kohn, R. (2009). Prevelance of mood, anxiety, and substance–abuse disorders for older Americans in the National Comorbidity Survey – Replication. *American Journal of Geriatric Psychiatry, 17*, 769–781. doi: 10.1097/JGP.0b013e3181ad4f5a

Hansen, C. J., Stevens, L. C., & Coast, R. J. (2001). Exercise duration and mood state: How much is enough to feel better? *Health Psychology, 20*, 267–275. doi: 10.1037/0278–6133.20.4.267

Hassmén, P., Koivula, N., & Uutela, A. (2000). Physical exercise and psychological well–being: A population study in Finland. *Preventative Medicine, 30,* 17–25. doi:10.1006/pmed.1999.0597

Herring, M. P., O'Connor, P. J., & Dishman, R. K. (2010). The effects of exercise training on anxiety symptoms among patients: A systematic review. *Archives of international medicine, 170*, 321–331.

Herring, M. P., Jacob, M. L., Suveg, C., Dishman, R. K., & O`Connor, P. J. (2012). Feasibility of exercise training for the short–term treatment of generalized anxiety disorder. *Psychotherapy and Psychosomatics, 8*1, 21–28.

Hoffman, P., 1997. The endorphin hypothesis. In: Morgan, W.P. (Ed.), *Physical Activity and Mental Health*. Taylor & Francis, Washington, DC, pp. 161–177.

Hoffmann–Smith, K. A., Ma, A., Cheng–Tsung, Y., Deguire, N. L., & Smith, J. P. (2009). The effect of tai chi in reducing anxiety in an ambulatory population. *Journal of Complementary and Integrative Medicine, 6*, 1553–1187. doi: 10.2202/1553–3840.1187

Hofmann, S. G., Litz, B. T., & Weathers, F. W. (2003). Social anxiety, depression, and PTSD in Vietnam veterans. *Journal of Anxiety Disorders, 17,* 573–582. doi: 10.1016/S0887–6185(02)00227–X

Hoge, C. W., Castro, C. A., Messer, S. C., McGurk, D., Cotting, D. I., & Koffman, R. L. (2004). Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care. *The New England Journal of Medicine, 351*, 13–22. doi: 10.1056/NEJMoa040603

Hoge, C. W., Terhakopain, A., Castro, C. A., Messer, S. C., & Engle, C. C. (2007). Association of posttraumatic stress disorder with somatic symptoms, health care visits, and absenteeism among Iraq war veterans. *American Journal of Psychiatry, 164*, 150–153.

Hopko, D. R., Lejuez, C. W., Ruggiero, K. J., & Eifert, G. H. (2003). Contemporary behavioral activation treatemtns for depression: Procedures, principles, and progress. *Clinical Psychology Review, 23,* 699–717. doi:10.1016/S0272–7358(03)00070–9

Jacobson, N. S., Dobson, K. S., Truax, P. A., Addis, M. E., Koerner, K., Gollan, J. K., et al. (1996). A component analysis of cognitive–behavioral treatment for depression.

Journal of Consulting and Clinical Psychology, 64, 295–304. doi: 10.1037/0022–006X.64.2.295

Jacobson, N. S., & Traux, P. (1991). Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. *Journal of Consulting and Clinical Psychology, 59*(1), 12–19.

Jukupcak, M., Roberts, L. J., Martell, C., Mulick, P., Michael, S., Reed, R., Balsam, K. F., Yoshimoto, D., & McFall, M. (2006). A pilot study of behavioral activation for veterans with posttraumatic stress disorder. *Journal of Traumatic Stress, 19*, 387–391. doi: 10.1002/jts.20125

Keane, T. M., Taylor, K. L., & Penk, W. E. (1997). Differentiating post–traumatic stress disorder (PTSD) from major depression (MDD) and generalized anxiety disorder (GAD). *Journal of Anxiety Disorders, 11*, 317–328. doi:10.1016/S0887–6185(97)00013–3

Keogh, E., Ayers, S., & Francis, H. (2002). Does anxiety sensitivity predict post–traumatic stress symptoms following childbirth? A preliminary report. *Cognitive Behavior Therapy, 31*, 145–155. doi:10.1080/165060702321138546

Kendall–Tackett, K. A., Williams, L. A., & Finkelhor, D. (1993). Impact of sexual abuse on children: A review and synthesis of recent empirical studies. Psychological Bulletin, 113, 164–180. doi: 10.1037/0033–2909.113.1.164

Kessler, R. C., Sonnega, A., Bromet, E., Hughes, M., & Nelson, C. B. (1995). Posttraumatic stress disorder in the National Comorbidity Survey. *Archives of General Psychiatry, 52*, 1048–1060. doi: 10.1001/archpsyc.1995.03950240066012

King, D. W., Leskin, G. A., King, L. A., & Weathers, F. W. (1998). Confirmatory factor analysis of the clinician–administered PTSD scale: Evidence for the dimensionality of posttraumatic stress disorder. *Psychological Assessment, 10*, 90–96. doi: 10.1037/1040–3590.10.2.90

Klimes–Dougan, B., Hastings, P. D., Granger, D. A., Usher, B. A., & Zahn–Waxler, C. (2001). Adrenocortical activity in at–risk and normally developing adolescents: Individual differences in salivary cortisol basal levels, diurnal variations, and responses to social challenges. *Development and Psychopathology, 13*(3), 695–719.

Koltyn, F., & Morgan, W. P. (1997). Influence of wet suit wear on anxiety responses to underwater exercise. *Undersea & hyperbaric medicine, 24*(1), 23–28.

Koss, M. P., Figueredo, A. J., & Prince, R. J. (2002). Cognitive mediation of rape's mental, physical and social health impact: Tests of four models in cross–sectional data. *Journal of Consulting and Clinical Psychology, 70*, 926–941. doi: 10.1037/0022–006X.70.4.926

Koszycki, D., Benger, M., Shlik, J., & Bradwejn, J. (2007). Randomized trial of a mediation–based stress reduction program and cognitive behaviour therapy in generalized social anxiety disorder. *Behaviour Research and Therapy, 45*, 2518–2526. doi:10.1016/j.brat.2007.04.011

Kulka, R. A., Schlenger, W. E., Fairbank, J. A., Hough, R. L., Jordan, B. K., Marmar, C. R., & Weiss, D. S. (1990). *Trauma and the Vietnam war generation*. New York: Brunner/Mazel.

Lamarch, L. J., & De Koninck, J. (2007). Sleep disturbances in adults with posttraumatic stress disorder: A review. *Journal of Clinical Psychiatry, 68*(8), 1257–1270.

Lang, A. J., Kennedy, C. M., & Stein, M. B. (2002). Anxiety sensitivity and PTSD among female victims of intimate partner violence. *Depression and Anxiety, 16*, 77–83. doi: 10.1002/da.10062

Lang, A. J., Laffaye, C., Satz, L. E., Dresslhaus, T. R., & Stein, M. B. (2003). Sensitivity and specificity of the PTSD checklist in detecting PTSD in female veterans in primary care. Journal of Traumatic Stress, 16, 257–264. doi: 10.1023/A:1023796007788

Leith, L. M. (1994). *Foundations of exercise and mental health*. Morgantown, WV: Fitness Information Technology.

Leong Lim, C., Byrne, C., & Lee, J. K. W. (2008). Human thermoregulation and measurement of body temperature in exercise and clinical settings. *Annals Academy of Medicine Singapore, 37*(4), 347–353.

Lilienfeld, S. O.,Turner, S. M., & Jacob, R. G. (1993). Anxiety sensitivity: An examination of theoretical and methodological issues. *Advances in Behaviour Research and Therapy, 15*, 147–183. doi:10.1016/0146–6402(93)90019–X

Long, B. C. (1983). Aerobic conditioning and stress reduction: Participation or conditioning? *Human Movement Science, 2*(3), 171–186.

Maker, A. H., Kemmelmeir, M., & Peterson, C. (2001). Child sexual abuse, peer sexual abuse, and sexual assault in adulthood: A multi–risk model of revictimization. *Journal of Traumatic stress, 14*, 351–368. doi: 10.1023/A:1011173103684

Manger, T. A., & Motta, R. W. (2005). The impact of an exercise program on posttraumatic stress disorder, anxiety, and depression. *International Journal of Emergency Mental Health, 7* (1), 49–57.

Merom, D., Phongsavan, P., Wagner, R., Chey, T., Marnane, C., Steel, Z.,Silove, D., & Bauman, A. (2007). Promoting walking as an adjunct intervention to group cognitive behavioral therapy for anxiety disorders – a pilot group randomized trial. *Journal of Anxiety Disorders, 22*, 959–968. doi:10.1016/j.janxdis.2007.09.010

Meyer, T., & Broocks, A. (2000). Therapeutic impact of exercise on psychiatric diseases: Guidelines for exercise testing and prescription. *Sports Medicine, 30*, 269–279.

Morgan, W. P. (1987). *Reduction of state anxiety following acute physical activity*. In W. P. Morgan & S. E. Goldston (Eds.), Exercise and mental health (pp. 105–109). Washington, DC: Hemisphere.

Morgan W. P. & Goldston S. E. (1987). *Exercise and mental health*. Washington, DC: Hemisphere Publishing Corp.

Morken, T., Magerøy, N., & Moen, B. E. (2007). Physical activity is associated with a low prevalence of musculoskeletal disorders in the Royal Norwegian Navy: A cross sectional study. *BMC Musculoskeletal Disorders, 8*, 1–8. doi:10.1186/1471–2474–8–56

Morgan W. P., & Goldston S. E. (1987). *Exercise and mental health*. Washington, DC: Hemisphere Publishing Corp.

Moshier, S. J., Hearon, B. A., Calkins, A. W., Szuhany, K. L., Utschig, A. C., Smits, J. A. J., & Otto, M. W. (2013). Clarifying the link between distress intolerance and exercise: Elevated anxiety sensitivity predicts less vigorous exercise. *Cognitive Therapy & Research, 37*, 476–482. doi: 10.1007/s10608–012–9489–9.

Mowrer, O. H. (1960). *Learning theory and behavior.* New York: Wiley.

McNally, R. J. (2002). Anxiety sensitivity and panic disorder. *Biological Psychiatry, 52*, 938–946. doi:10.1016/S0006–3223(02)01475–0

Nabkasorn, C., Miyai, N., Sootmongkol, A., Junprasert, S., Yamamoto, H., Arita, M., & Miyashita, K. (2005). Effects of physical exercise on depression neuroendocrine stress hormones and physiological fitness in adolescents females with depressive symptoms. *European Journal of Public Health, 16*, 179–184. doi: 10.1093/eurpub/cki159

National Center for PTSD (2007). *Using the PTSD Checklist (PCL)*. U.S. Department of Veterans Affairs. Retrieved from www.ptsd.va.gov June 24 2013.

Newman, C. L., & Motta, R. W. (2007). The effects of aerobic exercise on childhood PTSD, anxiety and depression. *International Journal of Emergency Mental Health, 9* (2), 133–158.

Nishith, P., Mechanic, M. B., & Resick, P. A. (2000). Prior interpersonal trauma: The contribution to current PTSD symptoms in female rape victims. *Journal of Abnormal Psychology, 109*, 20–25. doi: 10.1037/0021–843X.109.1.20

Norris, F. H. (1992). Epidemiology of trauma: Frequency and impact of different potentially traumatic events on different demographic groups. Journal of Consulting and Clinical Psychology, 60, 409–418. doi: 10.1037/0022–006X.60.3.409

O'Connor, P. J., Raglin, J. S., & Martinsen, E. W. (2000). Physical activity, anxiety and anxiety disorders. *International Journal of Sport Psychology, 31*(2), 136–155.

O'Connor, P. J., Smith, J. C., & Morgan, W. P. (2000). Physical activity does not provoke panic attacks in patients with panic disorder: A review of the evidence. *Anxiety, Stress and Coping: An International Journal, 13*, 335–353.

Ohayon, M. M. (2005). Prevalence and correlates of nonrestorative sleep complaints. *Archives of Internal medicine, 165*, 35–41.

Paluska, S.A., Schewnk, T.L., Paluska, S.A., & Schwenk, T.L. (2000). Physical activity and mental health: Current concepts. *Sports Medicine, 29*, 167–180.

Pelletier, L. G., Tuson, K. M., & Haddad, N. K. (1997). Client motivation for therapy scale: A measure of intrinsic motivation, extrinsic motivation, and a motivation for therapy. *Journal of Personality Assessment, 68*, 414–435. doi:10.1207/s15327752jpa6802_11

Penninx, B. W. J., Rejeski, W. J., Pandya, J., Miller, M. E., Bi Bari, M., Applegate, W. B., & Pahor, M. (2002). Exercise and depressive symptoms: A comparison of aerobic and resistance exercise effects of emotional and physical function in older persons with high and low depressive symptomatology. *The Journals of Gerontology, 57*, 124–132. doi: 10.1093/geronb/57.2.P124

Peronnet, F., Cleroux, J., Perrault, H., Cousineau, D., de Champlain, J., & Nadeau, R. (1981). Plasma norepinephrine response to exercise before and after training in humans. *Journal of Applied Physiology: Respiratory Environment Exercise Physiology, 51*(1), 812–815.

Pfaltz, M. C., Grossman, P., Michael, T., Margraf, J., & Wilhelm, F. H. (2010). Physical activity and respiratory behaviour in daily life of patients with panic disorder and healthy controls. *International Journal of Psychophysiology, 78,* 42–49. doi:10.1016/j.ijpsycho.2010.05.001

Pietrzak, R. H., Goldstein, M. B., Malley, J. C., Johnson, D. C., & Southwick, S. M. (2009). Subsyndromal posttraumatic stress disorder is associated with health and

psychosocial difficulties in veterans of operations Enduring Freedom and Iraqi Freedom. *Depression and Anxiety, 26*, 739–744. doi:10.1016/j.jad.2009.08.001

Prigerson, H. G., Macijewski, P. K., & Rosenheck, R. A. (2001). Combat trauma: Trauma with highest risk of delayed onset and unresolved posttraumatic stress disorder symptoms, unemployment, and abuse among men. *Journal of Nervous & Mental Disease, 189*(2), 99–108.

Public Health Agency of Canada. (2012). Physical Activity Tips for Adults (18–64 years). Retrieved March 26th 2012. http://www.phac–aspc.gc.ca/hp–ps/hl–mvs/pa–ap/07paap–eng.php.

Radloff, L. S. (1977). The CES–D Scale: A self–report depression scale for research in the general population. *Applied Psychological Measurement, 1*, 385–401. doi: 10.1177/014662167700100306

Reiss, S. (1991). Expectancy model of fear, anxiety, and panic. *Clinical Psychology Review, 11*, 141–153. doi:10.1016/0272–7358(91)90092–9

Reiss, S. & McNally, R. (1985). The expectancy model of fear. In Reiss, R., & Bootzin, R. R., (Eds.), *Theoretical Issues in Behaviour Therapy*. New York, NY, Academic Press: 107–121.

Regehr, C., Cadell, S., & Jansen, K. (1999), Perceptions of control and long–term recovery from rape. *American Journal of Orthopsychiatry, 69*, 110–115. DOI: 10.1037/h0080386

Rescorla, R. A. (1988). Pavlovian conditioning: It's not what you think it is. *American Psychologist, 43*, 151–160. doi: 10.1037/0003–066X.43.3.151

Resick, P. A., Monson, C. M., & Chard, K. M. (2010). *Cognitive processing therapy: veteran/military version. Therapist's manual*. National Center for PTSD, US Veteran's Affairs: Boston, VA.

Resick, P. A., Monson, C. M., & Rizvi, S. L. (2008). Posttraumatic stress disorder. In W. E. Craighead, D. J. Miklowitz, & L. W. Craighead (Eds.). *Psychopathology: History, diagnosis, and empirical foundations.* Wiley & Sons Inc.: New Jersey.

Richardson, D., Naifeh, J., & Elhai, J. (2007). Posttraumatic stress disorder and associated risk factors in Canadian peacekeeping veterans with health–related disabilities. *Canadian Journal of Psychiatry, 52*(8), 510–518.

Ross, R. J., Ball, W. A., Sullivan, K. A., & Caroff, S. N. (1989). Sleep disturbances as the hallmark of posttraumatic stress disorder. *American Journal of Psychiatry, 146*, 697–707.

Ruggiero, K. J., Del Ben, K., Scotti, J. R., & Rabalais, A. E. (2003). Psychometric properties of the PTSD Checklist – Civilian Version. *Journal of Traumatic Stress, 16*, 495–502. doi: 10.1023/A:1025714729117

Salmon, P. (2001). Effects of physical exercise on anxiety, depression, and sensitivity to stress: A unifying theory. *Clinical Psychology Review, 21*, 33–61. doi:10.1016/S0272–7358(99)00032–X

Sareen, J., Cox, B. J., Clara, I., & Asmundson, G. J. G. (2005). The relationship between anxiety disorders and physical disorders in the U.S. national Comorbidity Survey. *Depression and Anxiety, 21*, 193–202. doi: 10.1002/da.20072

Sareen, J., Cox, B. J., Stein, MB., Afifi, T. O., Fleet, C., & Asmundson, G. J. G. (2007). Physical and Mental Comorbidity, Disability, and Suicidal Behaviour Associated

with Posttraumatic stress disorder in a large community sample. *Psychosomatic Medicine, 69*, 242–248. doi: 10.1097/PSY.0b013e31803146d8

Schmidt, N. B., & Trakowski, J. (2004). Interoceptive assessment and exposure in panic disorder: A descriptive study. *Cognitive and Behavioral Practice, 11,* 81–92. doi:10.1016/S1077–7229(04)80010–5

Seidler, G. H., & Wagner, F. E. (2006). Comparing the efficacy of EMDR and trauma–focused cognitive–behavioral therapy in the treatment of PTSD: A meta–analytic study. *Psychological Medicine, 36,* 1515–1522. doi: 10.1017/S0033291706007963

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., ... Dunbar, G. C. (1998). The Mini–international neuropsychiatric interview (M.I.N.I.): The development and validation of a structured psychiatric interviewfor DSM–IV and ICD–10. *Journal of Clinical Psychiatry, 59*, [suppl 20], 22–33.

Sherman, M. D., Blevins, D., Kirchner, J., Ridener, L., & Jackson, T. (2008). Key factors in engaging significant others in the treatment of Vietnam veterans with PTSD. *Professional Psychology: Research and Practice, 39*, 443–450. doi: 10.1037/0735–7028.39.4.443

Shelby, R. A., Golden–Kreutz, D. M., & Anderson, B. L. (2005). Mismatch of posttraumatic stress disorder (PTSD) symptoms and DSM–IV symptom clusters in a cancer sample: Exploratory factor analysis of the PTSD Checklist–Civilian version. *Journal of Traumatic Stress, 18*, 347–357. doi: 10.1002/jts.20316

Sinyor, D., Schwartz, S. G., Peronnet, F., Brisson, G., & Seraganian, P. (1983). Aerobic fitness level and reactivity to psychosocial stress: Physiological, biochemical, and subjective measures. *Psychosomatic Medicine, 45*(3), 205–217.

Smits, J. A. J., Berry, A. C., Rosenfield, D., Powers, M. B., Behar, E., & Otto, M. (2008). Reducing anxiety sensitivity with exercise. *Depression and Anxiety*, *25*, 689–699. doi: 10.1002/da.20411

Smits, J. A. J., Meuret, A. E., Zvolensky, M. J., Rosenfield, D., & Seidel, A. (2008). The effects of acute exercise on CO2 challenge reactivity. *Journal of Psychiatric Research, 43,* 446–454. doi: 10.1016/j.jpsychires.2008.05.009

Spoont, M., Sayer, N., & Nelson, D. B. (2005). PTSD and treatment adherence: The role of health beliefs. *Journal of Nervous & Mental Disease, 193*, 515–522.

Spoormaker, V. I., & van den Bout, J. (2005). Depression and anxiety complaints; relations with sleep disturbances. *European Psychiatry, 20*, 243–245. doi:10.1016/j.eurpsy.2004.11.006

Stathopoulou, G., Power, M. B., Berry, A. C., Smits, J. A. J., & Otto, M. W. (2006). Exercise interventions for mental health: A quantitative and qualititative review. *Clinical Psychology: Science and Practice, 13*, 179–193. doi: 10.1111/j.1468–2850.2006.00021.x

Statistics Canada. (2011). Canadian health measures survey: Physical activity of youths and adults. Retrieved August12, 2011, http://www.statcan.gc.ca/daily–quotidien/110119/dq110119b–eng.htm.

Steinberg, H., & Sykes, E. A. (1985). Introduction to symposium on endorphins and behavioral processes; Review of literature on endorphins and exercise. *Pharmacology Biochemistry and Behaviour, 23*, 857–862. doi: 10.1016/0091–3057(85)90083–8

Stephens, T. (1988). Physical activity and mental health in the United States and Canada: Evidence from four popular surveys. *Preventative Medicine, 30*, 17–25. doi:10.1016/0091–7435(88)90070–9

Stephenson, K. L., Valentiner, D. P., Kumpula, M. J., & Orcutt, H. K. (2009). Anxiety sensitivity and posttrauma stress symptoms in female undergraduates following a campus shooting. *Journal of Traumatic Stress, 22*, 489–496. doi: 10.1002/jts.20457

Strohle, A (2009). Physical activity, exercise, depression and anxiety disorders. *Journal of Neural Transmission, 116,* 777–784. doi: 10.1007/s00702–008–0092–x

Sullivan, M. D., Katon, W. J., Russo, J. E., Frank, E., Barrett, J. E., Oxman, T. E., & Williams, J. W. (2003). Patient beliefs predict response to paroxetine among primary care patients with dysthymia and minor depression. *Journal of the American Board of Family Medicine, 16,* 22–31. doi: 10.3122/jabfm.16.1.22

Swift, D. L., Johannsen, N. M., Myers, V. H., Earnest, C. P., Smits, J. A. J., Blair, S. N. & Church, T. S. (2012). The effects of exercise training modality on serum brain derived neurotrophic factor levels in individuals with Type 2 Diabetes. *PLOS one, 7*(8), 1–7.

Taylor, S. (2000). *Understanding and treating panic disorder: Cognitive–behavioral approaches*. New York: Wiley.

Taylor, S., (2006). *Clinician's Guide to PTSD: A cognitive–behavioral approach*. The Guilford Press. New York NY.

Taylor, S., Koch, W. J., Woody, S., & McLean, P. (1996). Anxiety sensitivity and depression: How are they related? *Journal of Abnormal Psychology, 105*, 474–479. doi: 10.1037/0021

Taylor, S., Zvolensky, M., Cox, B., Deacon, B., Heimberg, R., Ledley, D, ... Cardenas, S. (2007). Robust dimensions of anxiety sensitivity: Development and initial validation of the Anxiety Sensitivity Index–3. *Psychological Assessment, 19*, 176–88. doi: 10.1037/1040–3590.19.2.176

Thompson, K. M., Crosby, R. D., Wonderlich, S. A., Mitchell, J. E., Redline, J., Demuth, G., Smyth, J., & Haseltine, B. (2003). Psychopathology and sexual trauma in childhood and adulthood. *Journal of Traumatic Stress, 16*, 35–38. doi: 10.1023/A:1022007327077

Van Amerigen, M., Mancini, C., Patterson, B., & Boyle, M. (2008). Posttraumatic stress disorder in Canada. *Neuroscience and Therapeutics*, *14*, 171–181. doi: 10.1111/j.1755–5949.2008.00049.x

Van Ommeren, M., Sharma, B., Sharma, G. K., Komproe, I., Cardena, E., & de Jong, J. T. V. M. (2002). The relationship between somatic and PTSD symptoms among Bhutanese refugee torture survivors: Examination of comorbidity with anxiety and depression. *Journal of Traumatic Stress, 15*, 415–421. doi: 10.1023/A:1020141510005

Wald, J., & Taylor, S. (2005). Interoceptive exposure therapy combined with trauma–related exposure therapy for post–traumatic stress disorder: A case report. *Cognitive Behaviour Therapy*, *34*, 34–40. doi:10.1080/16506070510010648

Wald, J., & Taylor, S. (2007). Efficacy of interoceptive exposure therapy combined with trauma–related exposure therapy for posttraumatic stress disorder: A pilot study. *Journal of Anxiety Disorders*, *21*, 8, 1050–1060. doi:10.1016/j.janxdis.2006.10.010

Wald, J., & Taylor, S. (2008). Responses to introspective exposure in people with posttraumatic stress disorder (PTSD): A preliminary analysis of induced anxiety reactions and trauma memories and their relationship to anxiety sensitivity and PTSD symptom severity. *Cognitive Behaviour Therapy, 37*, 90–100. doi:10.1080/16506070801969054

Wald, J., Taylor, S., Chiri, L. R., & Sica, C. (2009). Posttraumatic stress disorder and chronic pain arising from motor vehicle accidents: Efficacy of introspective exposure plus trauma–related exposure therapy. *Cognitive Behaviour Therapy*, *00*, 1–10. doi:10.1080/16506070903183570

Watt, M., Stewart, S., Birch, C., & Bernier, D. (2006). Breif CBT for high anxiety sensitivity decreases drinking problems, relief alcohol outcome expectancies, and conformity drinking motives: Evidence from a randomized controlled trial. *Journal of Mental Health, 15,* 683–695. doi:10.1080/09638230600998938.

Weathers, F. W., Litz, B. T., Herman, D. S., Huska, H. R., & Keane, T. M. (1994). *The PTSD Checklist (PCL–C): Reliability, validity, and diagnostic utility*. International Society for Traumatic Stress Studies, San Antonio, TX.

Westfall, P. H., & Young, S. S. (2003). *Resampling–based multiple testing.* John Wiley & Sons.

White, J. A., Ismail, A. H., & Bottoms, G. D. (1976). Effects of physical fitness on the adrenocortical response to exercise in stress. *Medical Science Sports, 8,* 113–118.

Wilson, D. (1985). *The "Fantastic Lifestyle Assessment"*. Department of Family Medicine, McMaster University, Hamilton, Ontario, Canada.

Winder, W. W., Hickson, R. C., Hagberg, J. M., Ehsani, A. A., & McLane, J. A. (1979). Training–induced changes in hormonal and metabolic responses to submaximal exercises. *Journal of Applied Physiology, 46*(4), 766–771.

Yehuda, R., Halligan, S. L., & Grossman, R. (2001). Childhood trauma and risk for PTSD: Relationship to intergenerational effects of trauma, parental PTSD, and cortisol excretion. *Development and Psychopathology, 13*(3), 733–753.

Youngstedt, S. D. (2005). Epidemiology of exercise and sleep. *Sleep and Biological Rhythms, 4*, 215–221. doi: 10.1111/j.1479–8425.2006.00235.x

Zinbarg, R. E., Barlow, D. H., & Brown, T. A. (1997). Hierarchical structure and general factor saturation of the Anxiety Sensitivity Index: Evidence and implications. *Psychological Assessment, 9*, 277–284. doi: 10.1037/1040–3590.9.3.277

Zvolensky, M. J., Forsyth, J. P., Bernstein, A., & Leen–Feldner, E. W. (2007). A concurrent test of the anxiety sensitivity taxon: Its relation to bodily vigilance and perceptions of control over anxiety–related events in a sample of young adults. *Journal of Cognitive Psychotherapy, 21*, 72–90. doi: 10.1891/08893907780493322

6.0 Appendices

6.1 Appendix A: List of Interoceptive Exposure Exercises.

1. Shake head from side to side (30 seconds)
2. Spin around in a swivel chair (60 seconds)
3. While sitting, bend over and place head between legs for 30 seconds then sit up quickly to a normal position
4. Hold breath (30 seconds)
5. Hyperventilate (i.e., breathing in and out rapidly; 60 seconds)
6. Breathe through a small, narrow straw (2 minutes; make sure not to breathe through your nose)
7. Tensing all the muscles in your body (60 seconds)
8. Run in place (or up/down stairs; 60 seconds)
9. Sit in a hot, stuffy room (e.g., hot car, facing a heater; 5 to 10 minutes)
10. Place a tongue depressor at the back of your tongue (30 seconds)
11. Drink a hot drink or wear warm clothing
12. Stare continuously at a spot on the wall (3 minutes)

6.2 Appendix B: Traumatic Life Events Checklist.

Many people have witnessed or experienced events (or a series of events) that are very distressing or traumatic. We are interested in knowing about distressing or traumatic events that you have witnessed or experienced at some point in your life.
Please put a check mark beside all of the events that you have witnessed or experienced.

- ❑ Natural disaster (e.g., tornado, flood)
- ❑ Motor vehicle accident
- ❑ Other serious accident (e.g., industrial, farm)
- ❑ Fire
- ❑ Seeing someone being seriously injured or killed
- ❑ Sexual assault as a child/adolescent
- ❑ Sexual assault as an adult
- ❑ Physical assault as a child/adolescent
- ❑ Physical assault as an adult
- ❑ Military combat or peacekeeping in a war zone
- ❑ Civilian (i.e., non–military) living in a war zone
- ❑ Terrorist attack
- ❑ Torture
- ❑ Unexpected death of loved one
- ❑ Armed robbery
- ❑ Serious illness (e.g., cancer, AIDS)
- ❑ Being publicly humiliated (worse than others)
- ❑ Being severely bullied, but not assaulted (worse than others)
- ❑ Being ridiculed (very badly teased, worse than others)
- ❑ The breakup of a significant relationship
- ❑ Other – Please specify _____

If you did not check any of the events, please SKIP to the next section. If you checked any of the events listed above, please continue with the questions in this section.
If you checked only one event, please SKIP to the next question. If you checked more than one of the events listed above, please indicate which one you are or were most distressed or traumatized by.

- ❑ Natural disaster (e.g., tornado, flood)
- ❑ Motor vehicle accident
- ❑ Other serious accident (e.g., industrial, farm)
- ❑ Fire
- ❑ Seeing someone being seriously injured or killed
- ❑ Sexual assault as a child/adolescent
- ❑ Sexual assault as an adult
- ❑ Physical assault as a child/adolescent
- ❑ Physical assault as an adult
- ❑ Military combat or peacekeeping in a war zone
- ❑ Civilian (i.e., non–military) living in a war zone
- ❑ Terrorist attack
- ❑ Torture
- ❑ Unexpected death of loved one

- ❑ Armed robbery
- ❑ Serious illness (e.g., cancer, AIDS)
- ❑ Being publicly humiliated (worse than others)
- ❑ Being severely bullied, but not assaulted (worse than others)
- ❑ Being ridiculed (very badly teased, worse than others)
- ❑ The breakup of a significant relationship
- ❑ Other – Please specify _____

The following questions are about the most distressing or traumatic event (or series of events) you have witnessed or experienced

Please answer the following questions with respect to the most distressing or traumatic event.

When did this event first occur?

- ❑ With the last month
- ❑ 1 to 3 months ago
- ❑ 4 to 6 months ago
- ❑ 7 months to 1 year ago
- ❑ 1 to 3 years ago
- ❑ 4 or more years ago

If the event occurred more than once, when did it last occur

- ❑ With the last month
- ❑ 1 to 3 months ago
- ❑ 4 to 6 months ago
- ❑ 7 months to 1 year ago
- ❑ 1 to 3 years ago
- ❑ 4 or more years ago

6.3 Appendix C: Posttraumatic Stress Disorder Checklist – Civilian Version

Instructions: Below is a list of problems and complaints that people sometimes have in response to stressful life experiences. Please indicate how much you have been bothered by that problem in the past month. Please rate as 1 for not at all; 2 a little bit; 3 moderately; 4 quite a bit; and 5 would be extremely.

	Not at all	A little bit	Moderately	Quite a bit	Extremely
1. Repeated, disturbing *memories, thoughts, or images* of a stressful experience from the past?	1	2	3	4	5
2. Repeated, disturbing *dreams* of a stressful experience from the past?	1	2	3	4	5
3. Suddenly *acting or feeling* as if a stressful experience from the past were happening again (as if you were reliving it)?	1	2	3	4	5
4. Feeling *very upset* when something reminded you of a stressful experience from the past?	1	2	3	4	5
5. Having *physical reactions* (e.g., heart pounding, trouble breathing, sweating) when something reminded you of a stressful experience from the past?	1	2	3	4	5
6. Avoiding *thinking about or talking about* a stressful experience from the past or avoiding *having feelings* related to it?	1	2	3	4	5
7. Avoiding *activities or situations* because *they reminded you* of a stressful experience from the past?	1	2	3	4	5
8. Trouble *remembering important parts* of a stressful experience from the past?	1	2	3	4	5
9. *Loss of interest* in activities that you used to enjoy?	1	2	3	4	5
10. *Feeling distant or cut off* from other people?	1	2	3	4	5
11. Feeling *emotionally numb* or being unable to have loving feelings for those close to you?	1	2	3	4	5
12. Feeling as if your *future somehow* will *be cut short*?	1	2	3	4	5

13. Trouble *falling or staying asleep*?	1	2	3	4	5
14. Feeling *irritable* or having *angry outbursts*?	1	2	3	4	5
15. Having *difficulty concentrating*?	1	2	3	4	5
16. Being "superalert" or watchful or on guard?	1	2	3	4	5
17. Feeling *jumpy* or easily startled?	1	2	3	4	5

6.4 Appendix D: Anxiety Sensitivity Index – 3

Please circle 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.

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

6.5 Appendix E: Center for Epidemiological Studies Depression Scale

	Rarely or none of the time (less than 1 day)	Some or a little of the time (1–2 days)	Occasionally or a moderate amount of the time (3–4 days)	Most or all of the time (5–7 days)
I was bothered by things that usually don't bother me	( )	( )	( )	( )
I did not feel like eating; my appetite was poor.	( )	( )	( )	( )
I felt that I could not shake off the blues, even with help from family and friends.	( )	( )	( )	( )
I felt that I was just as good as other people.	( )	( )	( )	( )
I had trouble keeping my mind on what I was doing.	( )	( )	( )	( )
I felt depressed.	( )	( )	( )	( )
I felt that everything I did was an effort.	( )	( )	( )	( )
I felt hopeful about the future.	( )	( )	( )	( )
I thought my life had been a failure.	( )	( )	( )	( )
I felt fearful.	( )	( )	( )	( )
My sleep was restless.	( )	( )	( )	( )
I was happy.	( )	( )	( )	( )
I talked less than usual.	( )	( )	( )	( )
I felt lonely.	( )	( )	( )	( )
People were unfriendly.	( )	( )	( )	( )
I enjoyed life.	( )	( )	( )	( )
I had crying spells.	( )	( )	( )	( )
I felt sad.	( )	( )	( )	( )
I felt that people disliked me.	( )	( )	( )	( )
I could not "get going".	( )	( )	( )	( )

6.6 Appendix F: Fantastic Lifestyle Questionnaire

INSTRUCTIONS: Unless otherwise specified, place and 'X' beside over the box which best describes your behaviour or situation in the past month.

Family / friends	I have someone to talk to about things that are important to me	Almost never	seldom	Some of the time	Fairly often	Almost always
	I give and receive affection	Almost never	seldom	Some of the time	Fairly often	Almost always
Activity	I am vigorously active for at least 30 minutes per day e.g., running, cycling, ect.	Less than once/week	1–2 times/ week	3 times/ week	4 times/week	5 or more times/week
	I am moderately active (gardening climbing stairs, walking, housework)	Less than once/week	1–2 times/ week	3 times/ week	4 times/week	5 or more times/week
Nutrition	I eat a balanced diet	Almost never	seldom	Some of the time	Fairly often	Almost always
	I often eat excess 1) sugar, or 2) salt, or 3) animal fats, or 4) junk foods	Four of these	Three of these	Two of these	One of theses	None of these
	I am within ____kg of my healthy weight	Not within 8 kg	8 kg (20lbs)	6 kg (15lbs)	4 kg (10lbs)	2 kg (5lbs)
Tobacco / toxins	I smoke tobacco	More than 10 times/week	1 – 10 times/ week	Non in the past 6 months	None in the past year	Non in the past 5 years
	I use drugs such as marijuana, cocaine	sometimes				Never
	I overuse prescribed or 'over the counter' drugs	Almost daily	Fairly often	Only occasionally	Almost never	Never
	I drink caffeine–containing coffee, tea, or cola	More than 10/day	7–10/day	3–6/day	1–2/day	Never
Alcohol	My average alcohol intake per week is ____	More than 20 drinks	13–20 drinks	11–12 drinks	8–10 drinks	0–7 drinks
	I drink more than four drinks on an occasion	Almost daily	Fairly often	Only occasionally	Almost never	Never
	I drive after drinking	Sometimes				Never
Sleep / seatbelts / stress / safe sex	I sleep well and feel rested	Almost never	seldom	Some of the time	Fairly often	Almost always
	I use seatbelts	Never	Seldom	Some of the time	Fairly often	Always
	I am able to cope with the stresses in my life	Almost never	Seldom	Some of the time	Fairly often	Almost always
	I relax and enjoy leisure time	Almost never	Seldom	Some of the time	Fairly often	Almost always
	I practice safe sex	Almost never	Seldom	Some of the time	Fairly often	Always

Type of behaviour	I seem to be in a hurry	Almost always	Fairly often	Some of the time	Seldom	Almost never
	I feel angry or hostile	Almost always	Fairly often	Some of the time	Seldom	Almost never
Insight	I am a positive or optimistic thinker	Almost never	seldom	Some of the time	Fairly often	Almost always
	I feel tense or uptight	Almost always	Fairly often	Some of the time	Seldom	Almost never
	I feel sad or depressed	Almost always	Fairly often	Some of the time	Seldom	Almost never
Career	I am satisfied with my job or role	Almost never	seldom	Some of the time	Fairly often	Almost always

6.7 Appendix G: Stages of Change Questionnaire

Physical activity can include such activities as walking, cycling, swimming, climbing the stairs, dancing, active gardening, walking to work, aerobics, sports, ect. Regular phsycial activity is 30 minutes of moderate activity accumulated over the day, almost every day OR...vigorous activity done at least three times per week for 20 minutes each time.

1. Here are a number of statements describing various levels of physical activity. Please select the one which most closely describes your own level:
O I am not physically active and I do not plan on becoming so in the next six months
O I am not physically active, but I have been thinking about becoming so in the next six months
O I am physically active once in a while, but not regularly
O I am currently physically active, but have only begun doing so within the last six months
O I participate in regular physical activity and have done so for more then six months

2. Answer if not currently active
I was physically active in the past, but not now. O YES O NO

6.8 Appendix H: Healthy Physical Activity Participation Questionnaire

1. Over a typical seven–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?
O At least three times
O Normally once or twice
O Rarely or never

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

3. In a general fashion, would you say that your current physical fitness is:
O Very good
O Good
O Average
O Poor
O Very poor

6.9 Appendix I: 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.

YES	NO	
O	O	1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
O	O	2. Do you feel pain in your chest when you do physical activity?
O	O	3. In the past month, have you had chest pain when you were not doing physical activity?
O	O	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
O	O	5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by change in your physical activity?
O	O	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
O	O	7. Do you know of any other reason why you should not do physical activity?

6.10 Appendix J: MINI Screener (Modified)

I am now going to ask you some questions about specific problems you may have had. Please answer yes or no to each question, unless I ask you to further describe – in which case, if we start to talk about something you prefer not to answer, just let me know and we can move on.

1. Have you been consistently depressed or down, most of the day, nearly every day, for the past two weeks?	Yes	No
2. In the past two weeks have you been much less interested in most things or much less able to enjoy the things you used to enjoy most of the time?	Yes	No
3. Have you ever had a period of time when you were feeling 'up' or 'high' or 'hyper' or so full of energy or full of yourself tat you got into trouble, or that other people thought you were not your usual self? (Not while under the influence of drugs or alcohol).	Yes	No
4. Have you ever been persistently irritable, for several days, to the point that you had arguments or verbal or physical fights, or shouted at people outside your family? Have you or others noticed that you over reacted to situations or been more irritable than usual compared to others – even in situations where you felt your reaction was justified?	Yes	No
5. Have you, on more than one occasion, had spells or attacks when you suddenly felt anxious, frightened, uncomfortable or uneasy, in situations where most people would not feel that way? During these spells did you have uncomfortable and frightening physical symptoms (e.g., heart racing, shortness of breath, feeling flushed, tingling in arms or hands)?	Yes	No
6. In the past month were you fearful or embarrassed of being watched, being the focus of attention, or fearful of being humiliated? (e.g., discomfort in social situations)	Yes	No
7. Have you worried excessively or been anxious about several things over the past six months?	Yes	No
8. In the past month have you been bothered by recurrent thoughts, impulses, or images that were unwanted, distasteful, inappropriate, intrusive, or distressing? (e.g., fears of contamination or germs, fears of harming others even though you didn't want to)	Yes	No
9. In the past month, did you do something repeatedly without being able to resist doing it, like washing or cleaning excessively, counting or checking things over and over, or repeating, collecting, or arranging things, or other superstitious rituals?	Yes	No
10. (a) have you ever experienced, witnessed, or had to deal with an extremely traumatic event that included actual or threatened death or serious injury to you or someone else?	Yes	No
(b) Did you respond to the event with intense fear, helplessness, or horror?	Yes	No
11. In the past 12 months, have you had 3 or more alcoholic drinks within a 3 hour period – on 3 or more occasions?	Yes	No
12. In the past 12 months, have you taken any street drugs more than once, to get high, to feel better, or to change you mood? (e.g., marijuana)	Yes	No
13. In the past three months, have you had problems with binge eating or not eating enough? Has anyone close to you – such as a family member or friend – expressed concern about you eating habits or weight?	Yes	No
14. In the past month, did you think that you would be better off dead or wished	Yes	No

that you were dead? IF YES, FOLLOW–UP WITH SUICIDE SCREEN

If yes to any of the above, which is of greatest distress (PTSD must be primary or secondary)

Primary: _____ Secondary:_____