The Effects of High Intensity Interval Training on PTSD Symptomology

by

Jacob Bryan
Bachelor of Science, University of Victoria, 2018

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

in the School of Exercise Science, Physical and Health Education

University of Victoria

We acknowledge with respect the Lekwungen peoples on whose traditional territory the university stands and the Songhees, Esquimalt and WSÁNEĆ peoples whose historical relationships with the land continue to this day.

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Dr. Kathy Gaul, School of Exercise Science, Physical and Health Education

Supervisor

Dr. Lynneth Stuart-Hill, School of Exercise Science, Physical and Health Education

Departmental Member

Dr. Tim Black, School of Educational Psychology and Leadership Studies

Outside Member

Abstract

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The purpose of this study was to determine the effect of high intensity interval training (HIIT) on post traumatic stress disorder (PTSD) and to compare the results of HIIT to a short, deep breathing session (BRTH) that is commonly used to manage PTSD symptoms. Previous research has demonstrated a positive effect of exercise on PTSD and related mental health concerns. Seven volunteers (six females and one male) participated in this study. All participants completed two groups of sessions, one comprised of three HIIT sessions and one of three BRTH sessions. Each group of sessions took place over approximately ten days, with a 4-week washout period between the two protocols. The HIIT sessions each involved eight sets of a work rest ratio of 20-second exercise to 10-second rest, with a 60-second break between the fourth and the fifth set for a total of 5 minutes. The BRTH sessions involved the use of an established 5-minute deep breathing PTSD therapy protocol. PTSD symptoms were measured using the PTSD Checklist (PCL). PCL measures were taken before (pre-test) and after (post-test) the intervention. Within the HIIT intervention, mean post-test Total PCL scores were significantly reduced compared to pre-test scores ($p < 0.005$), while BRTH scores did not significantly change. Two subscales in the PCL, Intrusion and Avoidance were also significantly reduced ($p < 0.0005$) following HIIT but not BRTH. All other subscales scores were lower following both HIIT and BRTH, though were not statistically significant different from pre-test values. No statistical between-

intervention differences were detected. The preliminary results from this research provide evidence that acute use of HIIT exercise provides similar or better positive effects on PTSD symptoms as BRTH and that HIIT exercise can be used as a symptom management tool for PTSD.

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Acknowledgements

I would like to thank my research assistants Shelby, Marie, Thomas, and Zach, for assisting me during the initial data collection of this study before we changed to online video conferencing. They were willing, able, and more than helpful to me during this stage, and I am thankful for their contributions.

Thank you to all the participants willing to volunteer for this study during the unprecedented COVID lockdowns.

Thank you to Dr. Kathy Gaul. When I began thinking about graduate school, a previous graduate student suggested you as a potential graduate supervisor. After meeting with you the first time, I knew that I had found my supervisor. I would not have been able to complete this project without you. Your guidance and insight were beyond anything I could have hoped for. We had to jump through dozens of hoops to make this study run smoothly and I was grateful to have you with me for every one of them.

Thank you to Dr. Lynneth Stuart-Hill. I remember being in one of your classes in my second year of my undergraduate degree and was inspired by your knowledge, passion, and kindness. I was thankful that we were able to bring you into this research project and I am grateful for the help you were able to provide.

Thank you to Dr. Tim Black. I do not think that I could have done this study without your assistance. Your insight into the PTSD community and your knowledge in how to approach this project was essential for me. When I pitched this idea to Dr. Gaul, she mentioned your name as a possible contact, and I was excited to meet with you and discuss my ideas. I never dreamed that

you would have been willing to join our team in this investigation. Our relationship extended beyond this project, and you were able to help me with another research project as well, which was a wonderful experience. I hope we can work together in the future.

I would like to thank my family and friends for their unwavering support and patience as I navigated this journey. My parents, Jeff and Michele, have encouraged me to pursue post-secondary education and have never ceased in their intensity of that encouragement and I am forever grateful. My brother, Josh, and his wife, Rebecca, were living with me during much of my graduate work and they were always willing to help when I needed a break or a laugh during the stressful times.

Finally, my wife, Jacqueline, who actually married me during this crazy journey! She deserves as much credit as anyone for this project. She was steadfast through all the craziness that comes with an undertaking like this. Her support throughout my schooling cannot be understated and I truly could not have done this without her.

Thank you.

1. Introduction

Post Traumatic Stress Disorder (PTSD) can arise in any person following a traumatic event or tragedy. It has been reported that up to 10% of the general population will suffer from PTSD at some point in their life (Asalgoo et al., 2014; Rosenbaum et al., 2015). Canada has the highest rates of lifetime PTSD prevalence in the world at 9.2% of the general population compared to the second highest country at 7.4%, The Netherlands, and the third highest 7.2%, Australia (Duckers et al., 2018). A positive PTSD diagnosis has been linked to many other types of health concerns. In fact, individuals with PTSD are up to 80% more likely to meet the criteria for other mental health disorders (APA, 2013; Blanco et al., 2013; Evren et al., 2011) and exhibit higher rates of social dysfunction and disturbed family dynamics, often associated with aggressive behaviours (Hoffman et al., 2015). PTSD severity is positively correlated with the risk of developing cardiovascular disease and, with this increase, a higher mortality risk (Vancampfort et al., 2016). PTSD has also been linked to poor health behaviours including sedentary lifestyles that increase the risk of developing cardiometabolic diseases such as type II diabetes, high cholesterol, issues with sleep quality, and metabolic disturbances (Blanco et al., 2013; Vancampfort et al., 2016; Rosenbaum et al., 2015). The field of PTSD research is actively exploring new ways to manage and treat the negative health impacts of PTSD (Grasser & Javanbakht, 2019).

Exercise might be the overlooked component in many mental health recovery programs, considering the strong scientific evidence surrounding the benefits of exercise on mental well-being (Rebar & Taylor, 2017). Exercise has been shown to benefit human psychological health, including positive effects on depression, anxiety, mood, and increased ability to cope with stress (Hoffman et al., 2015). Aerobic exercise, used therapeutically, has demonstrated similar

advantages on reducing depression when compared to anti-depressant medications, psychotherapy, and other more typical treatments (Dunn et al., 2001; Hegberg et al., 2019). Furthermore, exercise has shown to be effective in reducing the negative symptoms associated with PTSD by improving quality of sleep through its anti-depressive and anxiolytic effects (Rosenbaum et al., 2015).

When compared to pharmaceuticals and psychotherapy, exercise is inexpensive, accessible, has few negative side-effects and contraindications for those with PTSD, and can be performed at the convenience of the individual, all important factors for those with PTSD (Ottati & Ferraro, 2009). Psychotherapy can be effective at dealing with PTSD symptoms, however, seeing a physician or psychotherapist usually requires an appointment which typically takes several days or weeks to obtain. The acute psychological effects of exercise could be highly valuable to someone suffering acute from PTSD symptoms.

Research in the field of exercise and PTSD has focused on the use of aerobic exercise as the preferred modality to manage symptoms associated with PTSD (Hegberg et al., 2019). When individuals diagnosed with PTSD are experiencing acute or increased symptoms, they need a quick and helpful strategy to manage the symptoms. Exercise has the potential to fill this gap quickly and effectively (Rosenbaum et al., 2015). However, just as booking a therapy session can be time consuming, going for a 45-minute run or resistance training for an hour is as well; fortunately, there is a form of short duration exercise that fits this niche.

High Intensity Interval Training (HIIT), as a form of exercise, has recently begun to gain popularity as an effective way to attain both physical and psychological health benefits (Stamatakis et al., 2018). The Physical Activity Guidelines for Americans have recently removed the indication that exercise must be performed for 10 minutes or more to attain benefits, which

has increased the research and implementation of quick, high intensity exercise (Gibala & Little, 2021). HIIT is typically characterized as brief bursts of vigorous physical activity of less than 2 minutes near or above VO_2 max intensity, combined with short periods of rest (Stamatakis et al., 2018). In previous research, HIIT has been shown to initiated similar, or even greater, improvements in VO_2 maximum and peak, red blood cell volume, and stroke volume when compared to 30 or more minutes of moderate intensity continuous exercise like jogging or cycling (Chapman et al., 2017; Stamatakis et al., 2021; Gibala & Little, 2020). HIIT has also been shown to positively impact mental health conditions like depression and anxiety, two common issues linked to PTSD (Chapman et al., 2017).

There has been a recent increase in the use of non-traditional medicines and self-care techniques to assist PTSD sufferers beyond their normal treatment protocols (Kim et al., 2013). Non-traditional medicine like deep breathing techniques, in particular, have demonstrated reductions in PTSD symptom severity through activation of the parasympathetic nervous system (Morris & Wallace, 2018; Kim et al., 2013). A recent study tested the effectiveness of a deep breathing phone application for PTSD management and found clinically significant reductions in PCL scores after its use (Morris & Wallace, 2018). These findings in alternative medicines help to provide new paths for effective PTSD treatment. If quick and accessible self-care strategies like HIIT and deep breathing can demonstrate symptom reductions in PTSD they could be incorporated into standard care for those with PTSD. Therefore, the purpose of this study was to assess the effectiveness of HIIT as a form of acute symptom management for PTSD symptoms and to compare it with the known effects of a PTSD-specific deep breathing technique that takes a similar amount of time as HIIT.

1.1 Purpose and Rationale

PTSD is a debilitating disorder that can have profound effects on the daily lives of those that suffer from it. It is important to develop accessible strategies for dealing with the negative symptoms of PTSD. The purpose of this study was to evaluate the effectiveness of HIIT as a treatment option for acute PTSD symptomology when compared to a deep breathing (BRTH) exercise.

1.2 Research Questions

1) Do the HIIT and BRTH interventions influence self-reported PTSD symptomology?
2) Is there a difference between the effects of the HIIT and BRTH interventions on self-reported total PTSD Checklist (PCL) scores and their subscales?

1.3 Hypothesis

$H_0$1: The HIIT and BRTH interventions will not cause changes in PTSD symptomology between pre-intervention and post-intervention PCL scores.

$H_0$2: There will be no differences in PCL scores between the two HIIT and BRTH interventions.

1.4 Delimitations

1. The study was delimited to PTSD sufferers determined by a PCL score of 31 or above.
2. Only participants over the age of 18 were recruited for the study.
3. The participants required access to, and comfort in using, an online video conferencing platform.
4. Participants had to be able to perform high intensity exercise.

1.5 Limitations

1. With the addition of a new protocol in their lives, there may be a Hawthorne/Observer (Purssell et al., 2020) effect that could have influenced symptom reporting either positively or negatively.
2. This pre/post design study makes it difficult to conclude that the intervention was the direct cause of the changes as nothing was controlled for besides the interventions.

1.6 Assumptions

1. Participants all gave maximal effort during each exercise session.
2. Participants answered all questions on the PCL honestly and accurately to reflect their symptomology at the time they were completing the PCL

1.7 Operational Definitions

1. PTSD Symptomology (APA, 2013)

   All the symptoms associated with PTSD such as nervousness, anxiety, hyperactivity, lethargy, reliving experiences, negative thoughts, and avoidance.

2. PTSD Checklist (PCL)

   20-item self-report measure corresponding to the DSM-5 PTSD symptom criteria

3. Intrusion (PTSD symptom) (National Center for PTSD, 2021)

   Thoughts and memories of the traumatic event can return at any time. Also known as flashbacks.

4. Avoidance (PTSD symptom) (National Center for PTSD, 2021)

   Avoiding people, places, and activities that remind the individual of the trauma. Can also present as an individual trying to stay busy to avoid thinking about the traumatic event.

5. Cognition (PTSD symptom) (National Center for PTSD, 2021)

   Affects the way the individual perceives themselves and can alter the way the individual views others.

6. Arousal (PTSD symptom) (National Center for PTSD, 2021)

   Feeling of hypervigilance or hyperarousal. Individuals can feel jittery or on high alert for danger. Individual may experience sudden outbursts of anger and irritability, sleep difficulties, lack of concentration, and being startled by loud noises.

7. High Intensity Interval Training (HIIT)

   Bursts of high intensity exercise for 20 seconds interspersed with 10 second rest periods.

8. Breathing intervention (BRTH)

   A deep breathing technique from the PTSD Coach Canada phone application used to help manage PTSD symptoms.

9. Exercise

   Structured, planned, and goal driven repetitive body movements that have the intention of improving fitness.

10. Physical activity

    Physical movement carried out by the skeletal muscles of the body. Physical activity can be leisure activities such as gardening or sports like tennis.

2. Review of Literature

2.1 Introduction

Post Traumatic Stress Disorder (PTSD) was recognized as a psychiatric anxiety disorder in the Diagnostic and Statistical Manual of Mental Disorders (DSM) III in 1980 (APA, 2000). The American Psychiatric Association (2013) defined Post-Traumatic Stress Disorder (PTSD) by the following diagnostic criterion: (1) exposure to actual or threatened death, (2) presence of intrusion symptoms following, and associated with, the traumatic event, (3) avoidance of trauma associated stimuli and numbed responsiveness, (4) negative alterations in cognitions and mood associated with the traumatic event (5) hyperarousal and/or hypervigilance, (6) symptom presentation for more than one month, (7) impaired social, occupational or daily function, (8) disturbance is not attributable to the physiological effects of a substance or another medical condition. PTSD is characterized by four main symptoms; intrusion, avoidance, negative alterations in cognition and mood, and alterations in arousal and reactivity (Vancampfort et al., 2016; Sveen et al., 2015). Although PTSD has, only recently, been classified, the disorder itself has been around for thousands of years, dating back to as early as 2000 BCE (Asalgoo et al., 2015). There are reports of soldiers experiencing what we now understand as PTSD from the Battle of Marathon in Greece (450 BCE) and all through history up to World War I and II and beyond. However, these experiences were chalked up as cowardice, war fatigue, shell shock, concussions, among many others. Since World War I, the reports of post traumatic symptoms increased exponentially (Asalgoo et al., 2015). The scientific community recognized the debilitating experience of PTSD and realized that strategies to manage the symptoms needed to be developed (Herman, 2017).

Currently, common management of PTSD include pharmacological treatments like Sertaline HCl (ie. Zoloft) (Otatti & Ferraro, 2009) for the depression-like symptoms, selective serotonin reuptake inhibitors (SSRIs), and antipsychotics (Rosenbaum et al., 2015; Vancampfort et al., 2016). There are also non-pharmacological options that have been used independently, or in conjunction with pharmaceuticals, like Cognitive Behavioural Therapy (CBT), Prolonged Exposure Therapy, Cognitive Processing Therapy, Eye Movement Desensitization and Reprocessing therapy, aerobic exercise, and certain breathing therapy techniques (Cukor et al., 2009; Asalgoo et al., 2015; Kim et al., 2013; Shivakumar et al., 2017). Despite these many options, difficulties with treatment adherence and troubles finding the optimal treatment plan persist as demonstrated by the 36% dropout rate from trauma-focused therapies (Nixon & Sloan, 2017; Imel et al., 2013).

2.2 Prevalence of PTSD

Lifetime prevalence rates of PTSD are approximately 8.3% for the general population (Kilpatrick et al., 2013; Grasser & Javanbakht, 2019). The causes for PTSD are many, including motor vehicle accidents, natural disasters, combat exposure, sexual assault, serious illness, and unexpected deaths of close friends or family (Grasser & Javanbakht, 2019). PTSD research is particularly important in women in the general population as they are roughly twice as likely as men to develop PTSD (Grasser & Javanbakht, 2019). Findings from a national study found that approximately half of all women residing in the United States will experience a traumatic event at least once in their life (Mitchell et al., 2012) making gender-based PTSD research important. A high proportion of PTSD cases are associated with domestic abuse and partner violence (Cooper et al., 2020), which increase women's chances of developing PTSD. There are a number of theories surrounding why women are more susceptible to developing PTSD. One of the

theories seems to be related to women experiencing sexual assault on a more frequent basis and the experience of sexual assault is one of the most reported sources of PTSD (Resick et al., 2014; Grasser & Javanbakht, 2019). Comparatively, men experience PTSD less frequently but are also much less likely to seek out treatment for their symptoms and have an increased risk for suicide and substance abuse (Ronzitti et al., 2019).

There are particularly high numbers of PTSD in military veterans with some recent estimates suggesting that as high as 31% of United States combat veterans returning from Iraq and Afghanistan will be diagnosed with PTSD (Caddick & Smith, 2014). It is interesting to note that there are few differences between men and women in the military developing PTSD after experiencing combat-related trauma (Vogt et al., 2011). However, women are twice as likely to develop PTSD which illustrates the impact of the trauma experienced by women in a non-military setting.

2.3 Experiencing PTSD

There are four core symptom clusters associated with PTSD – intrusive thoughts, avoidance, negative alterations in mood and cognitions, and alterations in arousal and reactivity (Grasser & Javanbakht, 2019; Hegberg et al., 2019). Reexperiencing occurs when memories of the traumatic experience return, and this can happen at any time (National Center for PTSD, 2021; Hegberg et al., 2019). The person who is experiencing intrusive thoughts may feel the same intensity of fear or horror that was felt during the traumatic event (National Center for PTSD, 2021; Asalgoo et al., 2015). Having “flashbacks” is another common term for this symptom. Avoidance occurs when the individual actively avoids situations that remind them of the event that caused their PTSD (Hegberg et al., 2019). Avoidance is not limited to places or people, avoidance can involve changing one’s habits such as when the sufferer avoids driving

because their trauma stemmed from a motor vehicle accident or keeping very busy to limit the possibility of thinking about their trauma (National Center for PTSD, 2021; Asalgoo et al., 2015). Negative changes in cognition and mood affects the way the individual perceives themselves (National Center for PTSD, 2021; Asalgoo et al., 2010). This symptom can also present as not having positive feelings or love towards other people, leading to the possibility of avoiding future relationships (National Center for PTSD, 2021; Asalgoo et al., 2015). It can also cause the sufferer to forget parts of the PTSD-initiating traumatic event itself (Hegberg et al., 2019). Hyperarousal is the feeling of hypervigilance where the individual is jittery and on high alert for danger with the potential for sudden outbursts of anger or irritability (National Center for PTSD, 2021; Asalgoo et al., 2015). Examples of hyperarousal also include sleep difficulties, lack of concentration, and being startled by loud noises (National Center for PTSD, 2021; Descilo et al., 2010).

2.4 Assessment of PTSD Symptomology

The PCL (Appendix 1) was developed from the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) in which the four symptom clusters of PTSD are assessed, and the PCL is based on this section of the DSM-5. The DSM-5 is the standard reference tool for diagnosing and treating mental health (Blevins et al., 2015). The PCL is one of the most common self-report measures for those with PTSD (Blevins et al., 2015). The PCL uses a 5-point Likert scale to measure the intensity/frequency of each PTSD symptom from, 0 = “not at all” to 4 = “extremely” (Armour et al., 2016). The PCL has been revised recently to include three new questions (bringing the total to 20) that address a few new PTSD symptoms (blame, negative emotions, and reckless or self-destructive behaviour) as well as altering some of the wording in existing questions (Blevins et al., 2015). The newest version of the PCL made a change to the

numbering of the Likert system by changing the 5-point scale ranging from 1-5 to 0-4, which gives a person with no symptoms a “0” on the PCL rather than a “20” which could be confusing to those with no symptoms (Blevins et al., 2015).

The PCL has demonstrated high internal consistency in two separate studies (r=0.96 and r=0.95) for the total scores and comparable number for the subscales (Armour et al., 2016). Armour et al. (2016), reported alpha coefficients of 0.94 for Total PCL score, 0.85 for Intrusion, 0.85 for Avoidance, and 0.87 for Arousal. Additionally, Evren et al. (2011) reported Cronbach alpha scores for the PCL subscales and found they were acceptable to good (α = 0.57-0.78), while the Total PCL scale was assessed at high (α = 0.90). The PCL also boasts an excellent test-retest reliability ranging from 0.66 to 0.96, furthermore the PCL has good convergent reliability with correlations to other common PTSD measures ranging from 0.62 to 0.93 (Blevins et al., 2015). The PCL has been compared to the Clinician Administered PTSD Scale (CAPS) which is the gold standard in diagnosing PTSD and was found to be significantly correlated (Wolff et al., 2015). Overall, the PCL has been shown to have superb reliability and validity (Blevins et al., 2015).

2.5 Exercise and mental health

The physiological benefits of exercise and physical activity are well documented in the exercise-focused literature as well as the psychology-focused literature (Herbert et al., 2020; Hegberg et al., 2019; Elbe et al., 2019). Lack of physical activity has been linked to low cardiorespiratory fitness and nearly 20% of adult deaths have been attributed to physical inactivity (Pedersen, 2019). Physical inactivity is attributed to more adult deaths than obesity, smoking, diabetes, and high cholesterol combined (Pedersen, 2019). Chronic diseases such as cardiovascular disease, diabetes, cancer, and obesity often have a mental health component that

can help or hinder the individual's ability to recover from their ailment (Herbert et al., 2020). This suggests that exercise can help improve symptoms of chronic diseases while at the same time improving the mental health of these individuals and thus increase their chances of recovery. However, this information still begs the question, can exercise be used as a primary tool for combating mental health issues? A large U.S. population study concluded that there is a correlation between high frequency of physical activity and low frequency of poor mental health (Elbe et al., 2018; Chekroud et al., 2018). Furthermore, Chekroud et al. found that there was an optimal amount of exercise to maximize mental health improvements. They found that when individuals engaged in 45-minutes of exercise 3-5 days a week, their mental health was strongest which is suggestive of a U-shaped response to exercise (Chekroud et al., 2018). This finding is closely aligned with the Canadian Physical Activity recommendations of 150-minutes of exercise per week (CSEP, 2021).

Recent studies on university students have shown that those in university experience high levels of cognitive workload and are at risk for developing issues with their mental health, estimates have shown that up to 25% of university students will deal with mental health problems that require professional help (Herbert et al., 2020). However, studies have also shown that physical activity is positively correlated with reduced self-reported depressive symptoms, anxiety, positive affect, and quality of life in university students, regardless of gender and field of study which indicates its effectiveness in this population (Herbert et al., 2020).

Major depressive disorder is one of the most common mental health problems world-wide and is one of the leading contributors to the global burden of disease (Stubbs & Rosenbaum, 2018). Fortunately, not only has exercise been shown to be effective at combating mental health issues like depression, but it has also been shown to be protective against

depressive episodes in those who do not experience it on a regular basis (Stubbs & Rosenbaum, 2018). These protective effects are long-lasting, and it has been recently demonstrated that regular leisure time (at least one hour of physical activity per week) is associated with a lower risk of developing depression (Harvey et al., 2018).

Individuals who are currently suffering from depression will also reap the mental health rewards of exercise. Harris et al. (2006) found there was an inverse relationship between physical activity and depression severity. There are several theories as to how exercise helps our mental health, for example, the hypothalamic-pituitary-adrenal (HPA) axis releases cortisol when we experience stress and it has been suggested that exercise regulates depression by normalizing this system (Stranahan et al., 2008; Phillips, 2017). Investigations have also shown that physical activity has antidepressant effects, improves cognitive function and sleep, and optimizes brain-derived neurotropic factor levels (Phillips, 2017; Nota et al., 2020).

Anxiety disorders are the most common type of psychiatric disorders with a global prevalence rate of around 7% (Stubbs & Rosenbaum, 2018). Anxiety symptoms consist of unpleasant feelings of apprehension, insomnia, irritability, lack of concentration and thoughts of worry (Stubbs & Rosenbaum, 2018). Stemming from a single study in the 1960's (Pitts & McClure, 1967) there has been reluctance to using exercise as a treatment method for anxiety because it was believed that exercise would induce panic and potentially increase anxiety symptoms (Stubbs & Rosenbaum, 2018). However, since that time the opinion on exercise and anxiety has shifted dramatically. Experimental evidence has shown that a single exercise session is able to reduce anxiety symptoms (Motl et al., 2004). Research in the past decade indicates that exercise could be an effective treatment for anxiety when combined with traditional strategies (Kazeminia et al., 2020; Li et al., 2020).

2.6 Exercise and PTSD

The research around the interaction between exercise and PTSD is still fairly young, with a rapidly growing body of evidence showing that exercise can be an effective treatment for many mental health issues including PTSD (Zen et al., 2012; Adams et al., 2019; Goldstein et al., 2018; Li et al., 2020; Elbe et al., 2019). A significant portion of the research on PTSD includes military veterans and these studies have shown promising results for the efficacy of exercise as a treatment (Shivakumar et al., 2017; Whitworth et al., 2016; Adams et al., 2020; Fetzner & Asmundson, 2015). A survey, administered to a population of over one thousand U.S. military veterans, found that those who exercised 1-6 days per week had the lowest rates of PTSD symptoms and those who did not exercise had the highest prevalence of PTSD symptoms (Adams et al., 2019). They were also able to show that those who exercised more than three days per week were significantly less likely to experience PTSD symptoms when compared to those who exercised less than three days per week (Adams et al., 2019; Hegberg et al., 2013). Interestingly, those who reported exercising 7 days per week had similar rates of PTSD to those who did not exercise at all, which suggests that there is a limit to how much exercise can be performed before the benefits are compromised (Whitworth & Ciccolo, 2016; Adams et al. 2019). However, it is not clear whether the exercise caused to reduction in PTSD or that PTSD caused the reduction of exercise. This relationship does not demonstrate causation. Those with PTSD who exercise 7 days per week may be using exercise as a way to avoid intrusive thoughts and/or re-experiencing the traumatic event (Adams et al., 2019). Another important point to make about those who do not exercise at all, is that they are also at higher risk for other chronic diseases that accompany sedentary behaviour like heart disease, diabetes, and obesity (Adams et al., 2019).

More recent research has evaluated the effects that exercise has on PTSD symptoms directly. Shivakumar et al. (2017) measured the effects of a 12-week moderate-intensity exercise program on PTSD symptoms using the PCL as their measure. They were able to show significant reductions in PCL scores among other important measures, including the Clinician Administered PTSD Scale (CAPS) which is considered by many to be the gold standard in PTSD symptom reporting. In their study, Shivakumar et al. (2017), administered the PCL every week during the 12-week intervention and the results showed that the scores were decreasing week to week, on top of the significant reduction over the course of the study. Like depression, the reasons why exercise helps those with PTSD is not fully understood. Some have theorized that the HPA axis, catecholamines, and endogenous endorphins are regulated by exercise as their effects persist for up to 24 hours (Shivakumar et al., 2017). Also, exercise may help the body desensitize the internal arousal cues that previously stimulated negative responses and therefore have a positive effect on the experience of PTSD (Shivakumar et al., 2017; Adams et al., 2019). Brain-derived neurotropic factor (BDNF) has been suggested to play a role in the anti-depressive effects of exercise (Hoffman et al., 2015). When someone with PTSD responds to environmental stimuli, they can show down-regulated BDNF mRNA, meaning that they increase their sensitivity and therefore are at a higher risk for an extreme response (Hoffman et al., 2015). Exercise has been shown to increase BDNF and thus decrease the probability the individual will have an extreme response to normal stimuli (Fang et al., 2013). Finally, particularly low levels of cortisol are one of the distinct factors that distinguishes PTSD from other mental illnesses as low cortisol levels following a traumatic event are associated with an increased risk of developing PTSD (Dekel et al., 2013; Kim et al., 2013). The lower levels of cortisol in PTSD sufferers have been linked to increased negative feedback loop activity in the HPA axis, in which the brain is unable to supply

the normal amount of cortisol to maintain homeostasis (Dekel et al., 2013). This disruption in cortisol release can delay the ability of the individual to recover from the trauma and interfere with processing the trauma and can lead to long term issues associated with the traumatic event (Costa, 2016). Although cortisol levels are chronically low in PTSD sufferers, when re-experiencing the traumatic event, cortisol levels can be elevated beyond typical levels and lead to an intense stress response (Dekel et al., 2013). This finding, which is most often found in men, suggests that the range of cortisol levels is higher in PTSD sufferers and could account for the low cortisol levels at rest and the heightened levels when put in a stressful situation (Dekel et al., 2013). The research into the role that cortisol has with PTSD is still inconclusive, some studies suggest that there are sex-based differences in how cortisol impacts PTSD (Dekel et al., 2013). Exercise has been shown to increase levels of cortisol in the blood and this increase has been associated with PTSD symptom improvement (Aerni et al., 2004; Kim et al., 2013).

2.7 High Intensity Exercise

The World Health Organization (WHO) and many other public health agencies including the Canadian Physical Activity Guidelines recommend at least 150 minutes of moderate to vigorous physical activity per week (WHO, 2021). A common barrier to exercise is the time that is required to achieve the benefits of exercise (Reljic et al., 2021; Gillen et al., 2014). However, there has been a surge of research and popularity in short bursts of high intensity exercise and its efficacy on improving health. Recently, research has identified strategies that could allow exercisers to achieve the largest amount of benefit for the smallest amount of time investment. These strategies are widely known as high intensity exercise, of which there are several different approaches. The Tabata protocol is one of the more popular applications of high intensity exercise and uses interval training performed with intensities at, or above, 80% heart rate

maximum, which is very high (Murawska-Cialowicz et al., 2020; Tabata, 2019; Rognmo et al., 2004; Wisloff et al., 2007). The Tabata protocol involves alternating 20 seconds of intense exercise and 10 seconds of rest which is to be repeated 8 times, for a total exercise time of less than five minutes (Tabata, 2019; Murawska-Cialowicz et al., 2020).

The many benefits of high intensity exercise can rival and even exceed the benefits of traditional moderate intensity exercise practices like jogging or cycling (Murawska-Cialowicz et al., 2020; Gibala & Little, 2020). A common misconception surrounding high intensity exercise is that the sessions are too tiring and require peak levels of fitness (Murawska-Cialowicz et al., 2020; Gibala & Little, 2020). However, it has been shown that although the sessions are intense, they are not exhaustive because the sessions are short enough where the individual does not reach their absolute workload limit (Gibala & Little, 2020). The time spent exercising is much lower in high intensity exercise, but the benefits to VO_2 peak and VO_2 max appear to be similar to moderate intensity continuous exercise. For example, Gillen et al. (2014) compared a 10-minute protocol involving three intervals of high intensity cycling for 20-seconds to a 50-minute moderate-intensity continuous exercise protocol. Their study ran three times per week for six weeks. Both protocols improved VO_2 peak by 12% (Gillen et al., 2014). Comparable studies have demonstrated similar increases in VO_2 max in the ranges of 10 to 13% following a high intensity exercise protocol (Gibala & Little, 2020). The cause of the increase in cardiorespiratory health following high intensity exercise is still not fully understood, but it has been theorized that the main reason is expansion of red blood cell volume and the subsequent increase in stroke volume (Gibala & Little, 2020).

HIIT has been shown to improve other areas of our health. A recent study has shown that less than 30-minutes of HIIT per week can lead to significant improvements in cardiorespiratory

fitness, cardiometabolic risk, and was helpful for the reduction in body weight (Reljic et al., 2021). Other studies have shown that HIIT can improve glucose control and cause adaptations in skeletal muscle linked to improved metabolic health in individuals with type 2 diabetes (Little et al., 2011). High intensity exercise has shown increases in glucose transporter-4 (GLUT-4) expression and a reduction in insulin resistance for those suffering from diabetes (De Matos et al., 2018). Furthermore, high intensity exercise has demonstrated clinically significant improvements to body composition (body mass index, waist circumference, and fat mass percent) in younger obese individuals when performed for only 12-weeks (Khammassi et al., 2018). HIIT can also improve our sleep quality and therefore enhance our quality of life (Jimenez-Garcia et al., 2021). A study on older adults and HIIT was able to demonstrate statistically significant improvements in sleep following a HIIT protocol (Jimenez-Garcia et al., 2021). High intensity exercise has also been shown to be an effective strategy for sedentary and overweight/obese individuals contrary to previous beliefs that “non-athletes” would be unable to exercise at the aforementioned intensities (Murawska-Cialowicz et al., 2020).

2.8 Deep breathing and PTSD

A considerable portion of PTSD sufferers look outside traditional medicinal practices to manage their symptoms (Kim et al., 2013). It was reported that, in 2010, 39% of PTSD sufferers tried alternative medical strategies to manage their symptoms (Welder et al., 2006). Several studies have demonstrated the effectiveness of deep breathing and mindfulness strategies on PTSD symptomology (Kim et al., 2013; Descilo et al., 2010; Mitchell et al., 2014). Deep breathing has been established as an effective method to balance the autonomic nervous system through an increase in parasympathetic activity, which could have positive implications for the individual suffering from PTSD (Jerath et al., 2006). Deep breathing also increases

parasympathetic vagal nerve activity which leads to a more subdued psychophysiological response and decreased sympathetic activity (Kim et al., 2013). These changes are associated with a reduction in PTSD symptom severity (Kim et al., 2013). A study used a mind-body intervention, consisting of sixteen mind-body sessions of deep breathing and yoga-like movements, were able to show significant reduction (41%) in PCL scores and an increase (67%) in serum cortisol concentration, both have positive impacts on PTSD symptoms (Kim et al., 2013). Participants in this study reported improved sleep, stress resilience, and increased energy levels. They also reported a more regular participation in pleasurable activities that they had previously participated.

2.9 Summary

In summary, exercise and deep breathing, individually and used together, have been shown to reduce self-reported PTSD symptoms (Shivakumar et al., 2017; Adams et al., 2019; Kim et al., 2013). There are many different mechanisms that may be responsible for these reductions such as increases in cortisol and regulation of the HPA axis (Shivakumar et al., 2017; Adams et al., 2019). Daily PTSD experience can make life difficult and stressful, however there are many emerging strategies to deal with the symptoms.

One of these strategies is high intensity exercise, which has become popular recently due to its low cost, effectiveness, and its accessibility to all. The benefits of high intensity exercise are well-documented and have comparable physiological and psychological benefits to more traditional continuous moderate-intensity exercises like jogging or biking (Murawska-Cialowicz et al., 2020; Gibala & Little, 2020). A main draw to high intensity exercise is the short time commitments required to achieve maximum benefits (Gibala & Little, 2020).

The investigations into the effects of short high intensity exercise on mental health is new, but promising. The potential for a quick, low-cost, and effective strategy to help manage PTSD could make large differences in the daily lives of those suffering from this debilitating affliction.

3. Methods

3.1 Participants

Eight participants (6 female), between the ages of 19 and 75, who suffer from PTSD volunteered for this study. One volunteer did not meet the minimum PCL score of 31 to continue in the study. Therefore, seven participants, six female and one male, completed the study. All participants were informed of the study purpose, objectives, methods, procedures, risks, and benefits before signing a written consent form. This study was approved by UVIC Human Research Ethics Board (Appendix 2).

3.2 Recruitment

Posters, campus digicast graphics, email, newspaper advertisements, social media, and word-of-mouth were used to recruit participants for this study (Appendix 3). The advertisements asked, “Do you have PTSD?” and “Can you exercise?” to be as inclusive as possible because PTSD affects people from all walks of life. The posters (35cm x 19cm) were placed in community recreation centers, coffee shops, public pools, fire departments, private and public gyms, and around the University of Victoria campus. The campus digicast graphics were part of a running loop on monitors in most campus buildings for weeks before the study commenced and throughout the study. Two different graphics were used (one with a male image a one with a female image) to ensure that those viewing the graphic understood that this study had no gender restrictions.

3.3 Original, pre-COVID-19 pandemic, Research Design

Originally, this study was to be conducted in person, but due to COVID-19 related Public Health order restrictions had to shift to an online format. These changes in the research design and methodology allowed participants to complete their intervention protocols in an environment that was comfortable and convenient. The original design of this study included an additional

two variables, salivary cortisol, and heart rate variability (HRV), to reinforce the data from the PCL. Again, the COVID-19 related Public Health order restrictions halted the measurement of these variables as they required in-person sessions. The original design of the study also included three arms (HIIT, BRTH, Control), but due to the small sample size, time requirement, and the inconvenience of the pandemic-related limitations we decided to have all participants complete both the HIIT or BRTH intervention to maximize our data on the HIIT and BRTH conditions and drop the control arm.

3.4 Experimental design

A pseudo-randomized crossover design was used in this study. After providing the written consent (Appendix 4) and completing the Get Active Questionnaire (CSEP, 2021) (Appendix 5), participants filled out the PTSD Checklist to determine their baseline PTSD symptomology level. Participants were then assigned to one of two intervention groups, HIIT or BRTH.

The HIIT group completed the HIIT arm first, followed by the BRTH arm, separated by a 4-week washout period. The reverse occurred for the BRTH. Each arm consisted of three sessions spread out over approximately ten days, with at least four days between sessions to ensure adequate recovery from the exercise. After completing the third session, the participant filled out another PTSD Checklist as a post-intervention measure. After the first arm of the study was completed, the participants waited four weeks, as a washout period, before beginning the other arm of the study. In the second arm of the study, participants followed the same procedure as the first arm, the only part that changed was the protocol (HIIT or BRTH). An example participant timeline for all testing and interventions is provided in Figure 3.1. Participants were not required to alter anything in their daily lives throughout the duration of the study.

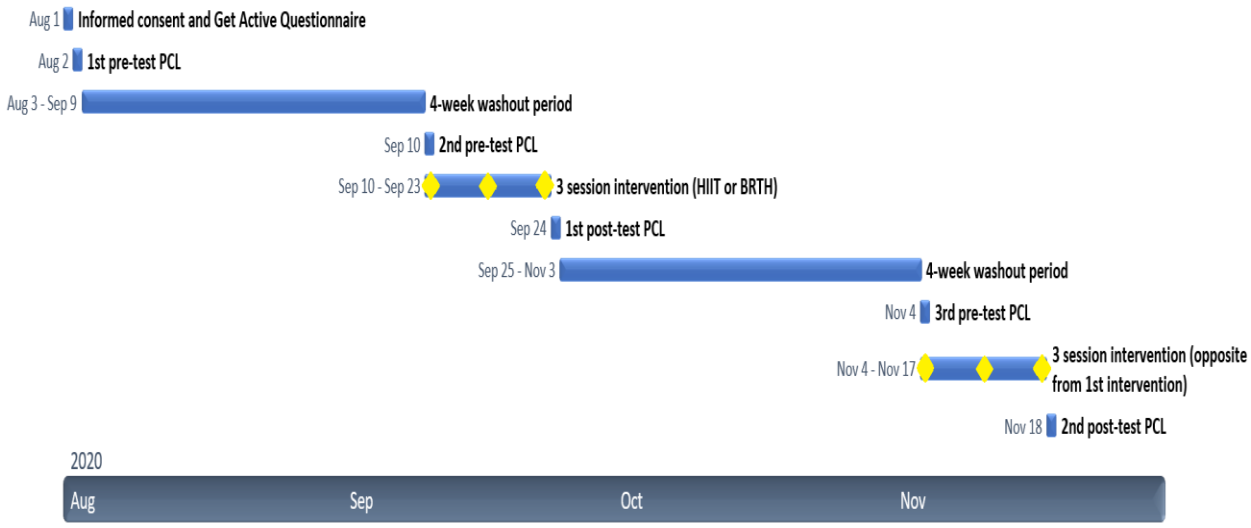

Figure 3.1. *Example study timeline for a participant beginning on August 1, 2020. Yellow diamonds indicate intervention sessions separated by four rest days.*

3.5 Experimental Testing Procedure

Before each session (BRTH or HIIT) participants signed onto their Zoom account and joined a meeting with the Principal Investigator (PI). The Zoom meetings were set up by the PI and individualized for each participant. The sessions were monitored by the PI for safety and technique. The Zoom meetings began with a short summary of the session. Once the participant was ready, they would begin their session, either HIIT or BRTH. Upon completion, the PI would schedule the next session or, if it was the last session, instruct them on the next steps for their post-test PCL measurement. Only the PI and the participant were present in each call. The PI was responsible for timing all aspects of the session and to maintain communication throughout the Zoom call.

The HIIT protocol utilized a Tabata-style exercise procedure (Appendix 6) managed with an interval timer workout phone application called Tabata Timer. Participants selected two forms of exercise from a pre-determined list (push-ups, jump squats, burpees, mountain climbers, or plank jacks). Each form of exercise selected was used in one of the two HIIT exercise sets within the session. The exercise procedure involved a twenty second interval of HIIT followed by ten seconds of rest, which was repeated four times for a total of eighty seconds of exercise. Participants were encouraged to complete as many reps as possible in the twenty second interval. After this first set of exercise, participants rested for sixty seconds before beginning their second set of HIIT, changing the form of exercise for this set. The second set proceeded with the same timing as the first set. In total, the participants exercised for two minutes and forty seconds, the entire session lasted five minutes.

The BRTH procedure also used a phone application as well (PTSD Coach Canada). The app was designed for those with PTSD to help manage their symptoms. Participants were asked to download the application onto their personal device and listen to the "Deep Breathing" tool in the "Manage Symptoms" section of the application. The BRTH session would talk the participants through a deep breathing exercise that was designed to promote breathing regulation and mindfulness. The entire session was monitored by the PI. The breathing session lasted for five minutes and twenty-seven seconds.

3.6 Statistical Analysis

Data were analyzed using the R 3.5.1. (R Core Team, 2018) statistical analysis software. The goal of the statistical analysis was to

(1) determine if there were differences between the first and second pre-test PCLs,

(2) evaluate the changes between pre-test and post-test means within each protocol (HIIT and BRTH),

(3) determine if there were differences in pre-test and post-test scores between the two protocols, and

(4) evaluate the response to each intervention by comparing the absolute and relative changes in the scores from pre-test to post-test.

Participants completed two pre-tests' PCLs before their first intervention to confirm a baseline score. As there was no statistical difference between the first pre-test PCL and the second pre-test PCL, we were able to confirm the consistency of the PCL. Consequently, this allowed us to use the second PCL as the baseline. We also compared the second pre-test PCL to the third pre-test PCL and found no statistical differences further confirming PCL consistency and the effectiveness of the 4-week washout period. To evaluate the effects of the first intervention, we then compared the second pre-test PCL to the first post-test PCL. To evaluate the effects of the second intervention, we compared the third pre-test PCL to the second post-test PCL.

Paired t-tests were performed within each intervention comparing pre-test and post-test scores to detect changes in the means of all those who completed that intervention. Between intervention differences were determined using t-tests for all PCL scores, including relative and absolute changes post-intervention. All statistical analyses included mean Total PCL scores and each of the four PCL subscales (Intrusion, Avoidance, Cognition, and Arousal). Statistical significance was set at $p < 0.05$ and all assumptions to perform t-tests were met.

4. Results

4.1 PTSD Checklist (PCL)

All seven participants, six females and one male (Mean age=40.4 ± 18.6 yrs), completed both arms (HIIT and BRTH) of the study. Although some participants began the study with HIIT and finished with BRTH, while the rest began with BRTH arm and finished with HIIT, all HIIT and BRTH data were combined regardless of which intervention the participant began with. All data were normally distributed.

As shown in Table 4.1, Total PCL scores were significantly reduced ($p < 0.005$) following the HIIT intervention compared to pre-test measures. Intrusion and Avoidance subscales scores were also significantly reduced ($p < 0.005$) (Appendix 7, Figures A7.1-7.2). All but three participants had reduced PCL scores after the HIIT protocol in all subscales. In the BRTH intervention, there was no statistically significant pre-test to post-test difference in the Total PCL scale (Table 4.1). Furthermore, there were no statistically significant changes in any of the subscales following the BRTH intervention (Appendix 7, Figures A7.1-7.2). Individual participant scores for Intrusion and Avoidance subscales are represented graphically (Appendix 7, Figures A7.3-7.6).

Mean HIIT and BRTH pre-test scores, including all subscales, were not statistically different (Table 4.1). This finding allowed for the detection of any between-intervention differences in the post-test PCL scores. No statistical difference in any scale or subscale was found between the HIIT and BRTH interventions at post-test, including the relative and absolute changes (Table 4.1). Pre and Post intervention Total PCL scores for both HIIT and BRTH is graphically represented in Figure 4.1 demonstrating a significant reduction post-HIIT only.

Figure 4.1 Mean (SD) PTSD Checklist (PCL) Total PCL scores (n=7)

+ significant difference between pre-test and post-test scores in HIIT intervention

Table 4.1 Mean (SD) PTSD Checklist (PCL) scores including subscale scores before (pre-test), after (post-test), within group p-values, absolute change in score, percent change in score, and between group p-values (n=7)

	Total PCL score			Intrusion PCL score			Avoidance PCL score			Cognition PCL score			Arousal PCL score		
	HIIT	BRTH	Between group p-value	HIIT	BRTH	Between group p-value	HIIT	BRTH	Between group p-value	HIIT	BRTH	Between group p-value	HIIT	BRTH	Between group p-value
Pre-test	38.4 (5.4)	39.9 (6.5)	0.683	8.6 (3.6)	7.9 (3.1)	0.220	5.0 (2.3)	5.4 (2.2)	0.736	15.1 (4.4)	16.3 (6.1)	0.655	9.7 (3.1)	10.3 (2.4)	0.547
Post-test	27.6 (8.7)	32.1 (11.0)	0.349	5.9 (3.6)	7.4 (6.1)	0.318	3.0 (2.5)	4.1 (4.1)	0.244	11.6 (6.2)	12.6 (7.0)	0.646	7.1 (2.0)	8.1 (1.5)	0.345
Within group p-value	0.002+	0.21		0.0003+	0.81		0.004+	0.23		0.056	0.28		0.056	0.12	
Mean absolute change	10.9 (5.6)	7.7 (14.6)	0.577	2.7 (1.0)	0.4 (4.4)	0.265	2.0 (1.2)	1.3 (2.6)	0.576	3.6 (4.0)	3.7 (8.2)	0.967	2.6 (2.9)	2.1 (3.1)	0.682
Mean percent change	34.0% (16.3)	17.1% (33.0)	0.351	42.0% (15.2)	12.3% (56.7)	0.290	54.5% (24.0)	9.5% (62.2)	0.191	30.6% (27.4)	15.7% (43.9)	0.581	27.5% (20.2)	16.3% (25.2)	0.482

+ significant differences between pre-test and post-test scores using paired t-tests

5. Discussion

To the best of our knowledge, this is the first study to demonstrate the positive impact that HIIT can have on PTSD symptomology. The results of this study show that the inclusion of HIIT into an individual's PTSD care could increase their ability to manage their symptoms. The HIIT intervention results were also compared to a deep breathing technique and demonstrated that HIIT was at least as effective, or better, than the BRTH technique and adds to the efficacy of the non-pharmacological treatments of PTSD. The fact that both have similar short time commitments (approximately five minutes) makes them that much more accessible. This deep breathing technique was designed by the U.S. Department of Veterans Affairs and the National Center for PTSD to help manage PTSD symptoms.

There have been several studies evaluating the effect of exercise on PTSD, most of these have primarily examined aerobic exercise in many different modalities (Descilo et al., 2010; Grasser & Javanbakht, 2019; Hegberg et al., 2019; Adams, et al., 2020). The aerobic exercise protocols in these studies typically took over thirty minutes to complete and thus presents a practical problem for those looking for quick and effective symptom management: time commitment. HIIT may be able to solve this issue. Exercise that takes too much time to complete has been cited as one of the most common barriers to exercise adherence and highlights the importance of reducing the exercise time, making HIIT an attractive option as it can be effectively completed in 5-10 minutes (Hegberg et al., 2019; Gillen et al., 2014; Gillen & Gibala, 2018; Korkiakangas et al., 2009).

Previous studies have reported lack of time being their main barrier to exercise, where participants stated they "are always so busy" or "irregular work hours, that's my main excuse for not exercising" (Korkiakangas et al., 2011; Korkiakangas et al., 2009). These time barriers can

be mitigated by HIIT. Previous studies using aerobic exercise were also able to show reductions in PTSD symptomology through several different measures, including the PCL, though not always statistically significant (Rosenbaum et al., 2015; Shivakumar et al., 2017).

The high intensity nature of the HIIT used in the current study was well tolerated by the participants with only mild soreness reported by some following the HIIT sessions. The online delivery of the interventions was initially a minor issue, however it eventually transitioned into a benefit for the participants because they learned that this type of exercise therapy could be done in the comfort of their own homes making it convenient, accessible, and simple to fit into their daily living. The participants were able to experience this versatility first-hand.

Approximately thirty people responded to the study recruitment materials. However, of those thirty, only the seven participants who consented and met the study requirements, completed the entire study. Consequently, there was a 0% attrition rate. This lack of attrition, which is highly unusual in exercise and mental health studies, reinforces the accessibility of a HIIT intervention for those with PTSD. Normal attrition rates for similar studies hover around 30% (Shivakumar et al., 2017). The small-time commitment required to complete our HIIT, the quickness of both the HIIT and BRTH protocols, and the ability to complete the interventions at home due to COVID restrictions may have also assisted in the very low attrition rate.

The mean pre-test HIIT and pre-test BRTH Total PCL scores were both above the predicted PTSD diagnosis cut-off score of 31 when using the PCL (National Center for PTSD, 2013). Following the HIIT intervention, the mean post-test Total PCL score was 27.6 (8.7), providing evidence that the HIIT intervention reduced the mean Total PCL scores to below the predicted PTSD diagnosis cut-off score on the PCL (National Center for PTSD, 2021). Following the HIIT intervention, four participants had PCL scores below the PTSD cut-off score

while following the BRTH intervention, two participants had PCL scores below the PTSD cut-off score. While these findings do not indicate that the participants no longer have PTSD, it does demonstrate the effect HIIT can have on the self-reported experience of the symptoms. After the first intervention period, participants returned to baseline levels of symptoms which indicates the acute symptom reduction effects of HIIT. PTSD is a daily struggle and any break from its symptoms is a welcome relief to those who suffer from them. The HIIT intervention was also able to produce significant reductions in two of the PTSD subscales, Intrusion (42.0% reduction) and Avoidance (54% reduction) in PCL scores (Appendix 7). An aerobic exercise and PTSD study that ran for two weeks, evaluated the subscales of the PCL as well and was able to find significant reductions in the Hyperarousal subscale but not the Intrusion or Avoidance PCL scores that were found in the current study (Fetzner & Asmundson, 2015). The interactions between exercise and the PCL subscales need more investigation. Recent studies about exercise and PTSD that have used the PCL as a measure have shown similar positive results, though few of these studies were able to show PTSD symptom reductions in ten days, as found in the current study. Although these studies were able to show significant reductions in PCL scores, they took 12 weeks to complete and had exercise protocols of at least twenty minutes, four times per week (Shivakumar et al., 2017; Rosenbaum et al., 2015). However, Fetzner & Asmundson (2015) used a six-session, 2-week study of 30-minute cycling sessions (including warm up and cool down) and was able to show significant reductions in the Hyperarousal subscale. No exercise and PTSD study to date has been able to show significant PCL score reductions in the Total, Intrusion, and Avoidance subscales together. The intervention in the current study was able to show significant results, in more subscales, took less time to complete, and did so with an exercise protocol of five minutes.

Following the BRTH intervention the post-test mean Total PCL score fell 17.1% (7.7 point). This reduction was not statistically significant, nor did it bring the mean score to below the predicted PTSD cut-off range. However, participants experienced some relief in self-reported symptoms and any amount of symptom reduction could have a positive impact the daily experience of the individual and reduce the burden of the chronic illnesses associated with PTSD (Goldstein et al., 2020; Shivakumar et al., 2017; Adams et al., 2020). One participant in particular experienced a large, 82.6%, (38 point), reduction in their Total PCL score following the BRTH intervention, with their score dropping from 46 at pre-test to just 8 in their post-test self-reported PTSD symptom experience over the 10-day BRTH intervention. The efficacy of the BRTH intervention varied considerably from participant to participant, with responses ranging from a 7-point increase to a 38-point reduction, as mentioned previously. This wide range of scores suggests that the BRTH strategy can have broadly different impacts, depending on the individual. Previous studies have attempted to validate deep breathing strategies with varying results. A study testing the effects of a deep breathing technique on PTSD in Vietnam veterans was unable to show statistically significant results (Watson et al., 1997). However, more recent studies have shown the effectiveness of deep breathing on PTSD and other stress-related disorders (Morris & Wallace, 2018; Brown et al., 2013). Morris and Wallace (2018) evaluated the effectiveness of a phone application developed for Android smartwatches called "BreatheWell". The application used slow and deep breathing to manage stress and found that half of their 14 participants (12 male and 2 female) experienced a reduction of five points or more on their PCL scores which indicates a reliable change in symptoms (National Center for PTSD, 2021). Furthermore, four of their participants experienced a reduction of ten points or more which represents a clinically significant change in symptoms (National Center for PTSD,

2021). Although the breathing technique used by Morris and Wallace (2018) is different than the one used in this current study, the results corroborate the results from Morris and Wallace (2018). This current study also saw a PCL reduction of five points or more from three participants (43%) following the BRTH intervention (Appendix 7, Figure A7.7), similar to the 50% reported by Morris and Wallace (2018). Another important point from the Morris and Wallace (2018) study was that only half of their participants had a reliable reduction in PCL scores (five points or more), which aligns with the results from this current study. This consistency in results contributes the varying effects that breathing strategies have on individuals.

The HIIT intervention demonstrated much more consistent individual results compared to the BRTH intervention. The HIIT intervention produced a 14-point range in Total PCL score reduction, with the largest reduction being a 19-point reduction and the smallest, a 5-point reduction (Appendix 7, Figure A7.8). Comparatively, the BRTH intervention showed a 45-point range in Total PCL individual score changes from pre-test to post-test (Appendix 7, Figure A7.7). Following the BRTH intervention, some participants reported feeling “calm and relaxed”, while others stated that they “didn’t feel any different” and “preferred the response they got from exercising”. Conversely, all participants reported that after the HIIT intervention they felt “good”, “energised”, and “more prepared to take on the day”.

That there were no differences between the pre-test scores of each intervention confirms the reliability of the PCL as previously reported by others (Blevins et al., 2015; Wolff et al., 2015). The lack of any difference between the mean post-test scores of each intervention indicates that the HIIT intervention in this study is at least as effective as the BRTH intervention

in helping reduce PTSD symptomology. This was further supported by the similar magnitude of both absolute and relative change that each intervention induced in PCL scores post-test.

There have been several theories as to why exercise is able to help manage PTSD symptoms. Most theories revolve around the neuroendocrine involvement of the hypothalamic-pituitary-adrenal (HPA) axis, catecholamines, and endorphins (Shivakumar et al., 2017). Each has been described as being compromised following a traumatic event in the studies of those with PTSD (Shivakumar et al., 2017). However, it has been shown that exercise may be able to regulate these systems and therefore manage the symptoms associated with PTSD (Adams et al., 2020; Whitworth & Ciccolo, 2016). It has been shown that exercise has positive effects on the HPA axis (Hegberg et al., 2019) and that exercise can increase blood cortisol levels which could help acutely correct the chronically low levels of cortisol found in those with PTSD (Chatzinikolaou et al., 2010). These findings contribute to the idea that exercise can be a good non-pharmacological option for PTSD symptom management and add to the growing idea that exercise can be used as medicine. Using the original design of this study, pre-pandemic, we had begun collecting saliva samples to test for salivary cortisol. This variable would have allowed us to show the effects that HIIT had on salivary cortisol levels, but unfortunately the pandemic-related restrictions prohibited the study to proceed as planned. Other theories suggest a more practical reason for the positive effects of exercise on PTSD and are centered around improvements in self-efficacy and self-esteem. The ability of the PTSD sufferer to take some control of their own recovery and symptom management, through the use of exercise, can be liberating and inspire confidence in the individual which leads to more effective self-care (Shivakumar et al., 2017).

Of note, the majority of participants in the present study were female. In the general population, women are twice as likely as men to develop PTSD but are also more likely to report their symptoms and seek help, highlighting the importance of research in this population because this it is willing to engage with PTSD treatment options more readily (Descilo et al., 2010; Mitchell et al., 2012). Most of the participants being female also highlight the potential of HIIT as an important management tool for PTSD in women (Descilo et al., 2010). Although only one male participated in this current study, the gendered nature of PTSD must be addressed as men are less likely to engage in treatment, or even report their PTSD symptoms (Ronzitti et al., 2020). A 2013 study with Iraq war veterans (Mittal et al.) with a predominantly male population pool (87.5%) reported that they resisted treatment because they felt they would be stereotyped as "crazy" or "violent". Some participants also felt that they would receive less sympathy from the public for combat-related PTSD compared to PTSD stemming from something like sexual assault, which is a much more common cause of PTSD in women (Mittal et al. 2013). Therefore, access to treatment and attempting to combat the stigmatization of PTSD could improve reporting and increase treatment adherence in the male population.

The benefits of exercise go beyond the potential reprieve that sufferers experience from their PTSD symptoms. Lack of exercise has been shown to have negative effects on multiple chronic diseases and health problems, many of which are common in PTSD sufferers (Adams et al., 2020). Some of the health problems linked to physical inactivity and PTSD include obesity, cancer, cardiovascular disease, diabetes, and high cholesterol (Pedersen, 2019). These health conditions can often be improved, at least a little, by increasing the amount of physical activity (Pederson, 2019; Gibala & Little, 2020). These improvements occur through several different pathways including an anti-inflammatory response in the body, reduction in blood pressure and

cholesterol, and lowering the risk of many types of cancers (Pedersen, 2019). Even if the individual does not experience significant reductions in their PTSD experience, they will be receiving benefits in other areas such as cardiovascular health, weight management, sedentary lifestyle, diabetes, hypertension, and many others (Gibala & Little, 2020).

Previous studies of exercise and PTSD have suggested that validated questionnaires and randomized control trials will need to be conducted to consolidate the relationship between exercise and PTSD (Whitworth & Ciccolo, 2016). This current study attempted to implement these suggestions by using a validated measure (PCL) and by using a pseudo-randomized strategy. Even with the implementation of these suggestions, further studies will have to be conducted to corroborate the results from this study.

5.1 Limitations

This study does have some limitations. Initially, the study was designed to include a non-intervention control arm in addition to the HIIT and BRTH interventions. Unfortunately, due to the low participant recruitment numbers and the difficulties linked to the COVID-19 related Public Health order restrictions, the control arm was eliminated to maximize the number of participants that would complete the HIIT and BRTH protocols. The potential of a Hawthorne or Observer effect influencing the results is recognized considering the lack of a non-intervention control. This study cannot rule out the possibility that the improvements shown in the results, by way of reduced PCL scores, are attributable to unknown factors. As the study took place at the height of the COVID-19 Provincial Health restrictions and could have provided a healthy break and/or change to the isolated lockdown experience of the individual participants which may have impacted the reporting of their symptoms. There is also a possibility that, due to the exercising nature of the study, those who volunteered to participate in the study enjoyed exercise already

resulting in a bias informing their responsiveness to HIIT. Lastly, the participant numbers were lower than anticipated in this study and limits the generalization of the results, particularly to the male population, considering all but one participant were female. These low participant numbers could have been caused by several factors: It has been shown that those with mental illness experience self-stigma, where the individual internalizes the public stereotypes and may reduce desire for treatment or treatment options (Mittal et al., 2013). It is possible that such self-stigma may have prevented those suffering with PTSD from volunteering for this study.

5.2 Conclusion

The HIIT intervention was able to demonstrate statistically significant reductions in the PCL scores from pre-test to post-test in the Total, Intrusion, and Avoidance scales. Although the BRTH intervention did not produce statistically significant results, the mean PCL scores trended downwards from pre-test to post-test. This study suggests that the accessible, inexpensive, and short time commitment of HIIT exercise could be integrated into typical PTSD care and produce meaningful results for the individual. The accessibility of HIIT would allow physicians to prescribe HIIT as a treatment option right away with low risk of adverse effects. The positive, although not statistically significant, results from the BRTH intervention add to the growing body of evidence surrounding the efficacy of breathing techniques to assist in PTSD symptom management. However, further studies are required to expand on this connection. This preliminary study shows the potential of non-pharmacological treatments, such as HIIT, as a management tool for PTSD symptoms.

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7. Appendix

Appendix 1 PTSD Checklist (Weathers et al., 2013)

greenspace

PTSD Checklist for DSM-V (PCL-5)

Below is a list of problems that people sometimes have in response to a very stressful experience. Please read each problem carefully and then circle one of the numbers to indicate *how much you have been bothered by that problem* ***in the past month.***

		Not at all	A little bit	Moderately	Quite a bit	Extremely
1.	Repeated, disturbing, and unwanted memories of the stressful experience?	0	1	2	3	4
2.	Repeated, disturbing dreams of the stressful experience?	0	1	2	3	4
3.	Suddenly feeling or acting as if the stressful experience were actually happening again (as if you were actually back there reliving it)?	0	1	2	3	4
4.	Feeling very upset when something reminded you of the stressful experience?	0	1	2	3	4
5.	Having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)?	0	1	2	3	4
6.	Avoiding memories, thoughts, or feelings related to the stressful experience?	0	1	2	3	4
7.	Avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)?	0	1	2	3	4
8.	Trouble remembering important parts of the stressful experience?	0	1	2	3	4
9.	Having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)?	0	1	2	3	4
10.	Blaming yourself or someone else for the stressful experience or what happened after it?	0	1	2	3	4

		Not at all	A little bit	Moderately	Quite a bit	Extremely
11.	Having strong negative feelings such as fear, horror, anger, guilt, or shame?	0	1	2	3	4
12.	Loss of interest in activities that you used to enjoy?	0	1	2	3	4
13.	Feeling distant or cut off from other people?	0	1	2	3	4
14.	Trouble experiencing positive feelings (for example, being unable to feel happiness or have loving feelings for people close to you)?	0	1	2	3	4
15.	Irritable behavior, angry outbursts, or acting aggressively?	0	1	2	3	4
16.	Taking too many risks or doing things that could cause you harm?	0	1	2	3	4
17.	Being “superalert” or watchful or on guard?	0	1	2	3	4
18.	Feeling jumpy or easily startled?	0	1	2	3	4
19.	Having difficulty concentrating?	0	1	2	3	4
20.	Trouble falling or staying asleep?	0	1	2	3	4

Appendix 2 Ethics

University of Victoria
Office of Research Services | Human Research Ethics Board
Michael Williams Building Rm B202 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
T 250-472-4545 | F 250-721-8960 | uvic.ca/research | ethics@uvic.ca

Certificate of Approval - Annual Renewal

PRINCIPAL INVESTIGATOR	**Kathy Gaul** (Supervisor)	**ETHICS PROTOCOL NUMBER** Board member review - delegated	**19-0414**
PRINCIPAL APPLICANT	**Jake Bryan** **Master's student**	ORIGINAL APPROVAL DATE	06-Jan-2020
		APPROVED ON	13-Jan-2021
UVIC DEPARTMENT	**Exercise Science, Physical and Health Education EPHE**	APPROVAL EXPIRY DATE	05-Jan-2022

PROJECT TITLE **The effects of High intensity interval training on PTSD symptomology**

RESEARCH TEAM MEMBERS
Timothy Black - RESEARCH SUPPORT, UVIC
Lynneth Stuart-Hill - RESEARCH SUPPORT, UVIC
Marie Fish - Research Support/assistant, UVIC
Zach Wear - Research assistant, UVIC
Shelby DeNat - Research Support/assistant, UVIC
Thomas Service - Research assistant, UVIC

DECLARED PROJECT FUNDING **None**

DOCUMENTS INCLUDED IN THIS APPROVAL
OHSE _ Biosafety Awareness_Certificate of Completion.pdf - 16-Oct-2019
OHSE WHMIS 2015_Certificate of Completion.pdf - 16-Oct-2019
DSM 5 - PCL.pdf - 07-Nov-2019
Study design.jpg - 08-Nov-2019
CSEP Get Active FULL document.pdf - 12-Dec-2019
Terms and Conditions - Breathing app.docx - 14-Dec-2019
PTSD Breathing app script.docx - 14-Dec-2019
Verification_of_BiosafetyRegistration Gaul-Dec2019.pdf - 18-Dec-2019
Recruitment Poster.docx - 27-Dec-2019
Verification_of_Registration Gaul.pdf - 20-Jan-2020
ZachWear OHSE-WHMIS_Certificate_of_Completion.pdf - 12-Mar-2020
ZachWear-OHSE-BioSafetyAwareness_Certificate_of_Completion.pdf - 12-Mar-2020
TService-OHSE-WHMIS-Certificate_of_Completion.pdf - 13-Mar-2020
TService OHSE-Biosafety Awareness-Certificate_of_Completion.pdf - 13-Mar-2020
MarieFish-OHSE-BiosafetyAwareness Certificates.pdf - 13-Mar-2020
HIIT group handout - daily activity.docx - 10-Jun-2020
Breathing group handout.docx - 10-Jun-2020
Control group handout.docx - 10-Jun-2020
Script for phone calls.docx - 11-Jun-2020
Participant tracking sheet.docx - 11-Jun-2020
Recruitment e-mail original.docx - 16-Jun-2020
Consent Form Original.docx - 16-Jun-2020
Recruitment e-mail NEW.docx - 19-Jun-2020
Consent Form NEW.docx - 24-Jun-2020
Amendment - Consent Form.docx - 25-Jun-2020

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropiate standards of ethcis as outlines by the University of Victoria Research Regulations Involving Human Participants.

[redacted]

Dr. Rachael Scarth
Associate VP Research Operations

Certificate Issued On: 13-Jan-2021

Appendix 3 Recruitment Materials

Do you have PTSD?

Are you able to do 5 minutes of High Intensity Exercise?

STUDY PARTICIPANTS NEEDED

We want to know if High Intensity Interval Training (HIIT) can be used a treatment option for PTSD symptoms. The study will consist of a 10-day intervention with 3 HIIT sessions.

If you are over the age of 18, have PTSD (diagnosis determined via the PTSD Checklist), are able to do high intensity exercise, and would like to participate in a research study:

CALL JAKE AT
(250)516-8352
or EMAIL AT
jkbryan@uvic.ca

Jake Bryan – University of Victoria Graduate Student
Dr. Kathy Gaul – Supervisor – kgaul@uvic.ca
This study is approved by the Human Research Ethics Board

University of Victoria

Jake Bryan (250) 516-8352 jkbryan@uvic.ca

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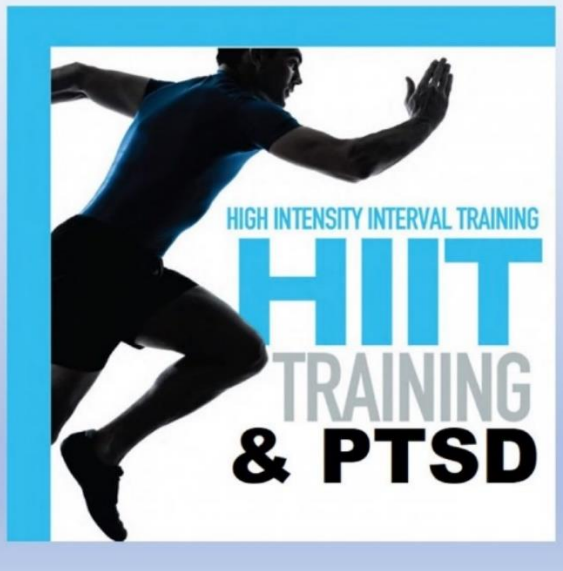

DO YOU HAVE PTSD?

EXERCISE MIGHT HELP YOU!

Recruiting research study participants (18 years or older) to determine if High Intensity Interval exercise can help reduce your PTSD. To find out more, please contact: jkbryan@uvic.ca.

DO YOU HAVE PTSD?

EXERCISE MIGHT HELP YOU!

Recruiting research study participants (18 years or older) to determine if High Intensity Interval exercise can help reduce your PTSD. To find out more, please contact: jkbryan@uvic.ca.

Appendix 4 Consent Form

University of Victoria | School of Exercise Science, Physical & Health Education

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The Efficacy of High Intensity Interval Training as a Treatment for Post Traumatic Stress Disorder

You are invited to participate in a study entitled **The Efficacy of High Intensity Interval Training as a Treatment for Post Traumatic Stress Disorder** that is being conducted by Jake Bryan (MSc. Kinesiology Candidate). Jake is a graduate student in the department of Exercise Science, Physical and Health Education at the University of Victoria and you may contact him if you have any further questions by phone: (250) 516-8352, or email: jkbryan@uvic.ca

As a graduate student, I am required to conduct research as part of the requirements for a Master of Science in Kinesiology. It is being conducted under the supervision of Dr. Kathy Gaul. You may contact my supervisor by phone: (250) 721-8380, or email: kgaul@uvic.ca

Purpose and Objectives

The purpose of this study is to evaluate the effectiveness of High Intensity Interval Training (HIIT) as a treatment option for managing PTSD symptomology. The efficacy of HIIT as a treatment option could be valuable to PTSD sufferers in day-to-day living when they need to face a situation that they recognize could elicit an atypical response due to their PTSD diagnosis. This exercise treatment may increase the ability to deal with PTSD symptoms independent of health care givers and pharmaceuticals, and therefore regain some of their autonomy and self-efficacy.

Importance of this Research

Research of this type could be valuable to an individual suffering from PTSD. Although there are several options for treating PTSD symptomology, most of them have a latency period or are meant to manage symptoms long term. Those with PTSD lack an option for acute symptom management besides the breathing technique outlined in this study. However, the breathing technique does not work for everyone. Giving this population a strategy to manage their symptoms quickly, in any location and by themselves could be empowering. Testing the effectiveness of HIIT in this study could open the door to more “exercise as medicine” research in the field of PTSD treatment, and the management of general health of those with PTSD.

Participants Selection

You are being asked to participate in this study due to your diagnosis of Post Traumatic Stress Disorder and your willingness to complete a high intensity exercise program.

What is involved?

This study involves the following procedures and protocols:

Before the first session of the intervention (after the consent forms have been signed), each participant will be assigned a participant number. This number, rather than name, will be used throughout the study to ensure confidentiality of the results. After numbers have been assigned, an online randomizer will place participants into one of three groups, the HIIT group, the Breathing group, or the Control group.

All sessions will take place in the participant's own home or safe preferred location, with sessions conducted by the primary investigator (Jake Bryan) remotely using an online video conferencing application like Zoom or Skype. Participants in each group will complete three sessions spread out over ten days.

Before the intervention begins, all participants will have a PTSD Checklist emailed to them, which is to be filled out and returned, at least one-week prior to the start of the intervention to establish a baseline PTSD checklist score.

Overview

HIIT Group

Day 1: Introduction to the HIIT protocol and demonstrations of all exercise options. Participants will then fill out a second baseline PCL to ensure baseline scores are accurate. Participants will then complete a 5-minute warm-up followed by their HIIT protocol that will last approximately 5-minutes and finally their 5-minute cool-down.

Day 2: Follow the same timeline as Day 1, excluding the introductory component and the PTSD checklist.

Day 3: Follow the same timeline as Day 1, excluding the introductory component, but will include the third PTSD Checklist.

Breathing Group

Day 1: Participants will be introduced to the PTSD Coach Canada phone application that helps PTSD sufferers deal with their symptoms in a multitude of ways. They will then be shown how to access the "Slow Breathing" section that they will use in the study. The breathing application will not require any personal information from the participants and therefore ensure confidentiality and anonymity. Participants will then fill out a second baseline PCL to ensure baseline scores are accurate. The Breathing protocol will last approximately 5-minutes.

Day 2: Follow the same timeline as Day 1, excluding the introductory component and the PTSD checklist.

Day 3: Follow the same timeline as Day 1, excluding the introductory component, but will include the third PTSD Checklist.

Control Group

Day 1: Participants will fill out the second PTSD Checklist to ensure baseline scores are accurate.

Day 2: Participants will maintain their daily lives (no action needed for study purposes).

Day 3: Participants will fill out the third PTSD Checklist.

HIIT Exercises Options:

Burpees, mountain climbers, push-ups, plank jacks, and squat jumps

Number of repetitions during each 20 second set will be recorded by research assistants

Exercise Options for those with disabilities:

Wheelchair push-ups, arm jacks, shadow boxing, and alternating shoulder press

Number of repetitions during each 20 second set will be recorded by research assistants

Breathing Protocol:

The breathing protocol from the PTSD Coach Canada will only have one option

Prior to each HIIT session participants will check in to report any injuries sustained outside of the study that would prohibit them from participation in the exercises. Jake Bryan will demonstrate all the exercises before initiating in the HIIT protocol to ensure proper technique is being used.

Detailed Overview

Pre-intervention

After completing the consent form, Jake Bryan will email the first of two pre-intervention PTSD checklists. The participant will fill out the checklist and email it back to Jake Bryan, if the participants score is 31 or over, they will be permitted to continue in the study. This will serve as the first of two baseline measures. The PTSD checklist requires the individual to recall the previous month's symptoms, so by having two baseline measures it will give the researcher a better insight into the baseline PTSD checklist score of each participant. Once this first PTSD Checklist is completed, the participants will wait at least one-week before the beginning of the intervention phase. Once the first PTSD checklists have been returned to Jake Bryan, and their scores evaluated, the participants will be randomized into one of three groups: the HIIT group, the Breathing group or the Control group.

Day One (one month after completing the first PTSD checklist)

HIIT group: After signing into their video conferencing application with Jake Bryan the participants will fill out their second of two PTSD checklists which will complete the pre-intervention baselines, they will be given time to fill out their PTSD checklist in private, before beginning their exercise protocol. Upon completion of the PTSD checklist, participants will receive a detailed description of each exercise option they can choose from. They will need to select two of the five exercise options for their HIIT protocol for Day One.

The participant will lie down quietly for 5-minutes. The participant will complete their HIIT protocol with their selected exercises. This exercise session will take approximately 5-minutes. After completing the exercise, the participant will sit/lie down to return to resting state. After the participant has returned to a resting state and has met the CSEP cool down protocols, the session is complete.

Breathing group: After signing into their video conferencing application with Jake Bryan the participant will fill out their second of two PTSD checklists which will complete the pre-intervention baselines, they will be given time to fill out their PTSD checklist in private, before beginning their breathing protocol.

The participant will complete their 5-minute Breathing protocol in the PTSD Coach Canada application.

Control group: The participants will be provided with their second baseline PTSD checklist. The participant will be asked to fill out the PTSD checklist on the same day as Day One of the intervention.

Day Two (Four days after Day One)

HIIT group: The second session will proceed in a similar fashion to Day One and complete the HIIT session.

Breathing group: The second session will proceed in a similar fashion as Day One.

Control group: No action required for Day Two.

Day Three (Four days after Day Two)

HIIT group: The third (final session of group) will be run the same as the first. The third PTSD Checklist will be completed following that session.

Breathing group: The third (final session of group) will be run the same as the first. The third PTSD Checklist will be completed following that session.

Control group: Their third PTSD checklist will be filled out and returned.

Post-intervention

All groups: After the conclusion of the intervention (Day Three), the participant will be given a follow-up PTSD checklist. One month after Day Three, the participants will be asked to fill out the last PTSD Checklist.

Those who were randomized into the Breathing group or the Control group will be given an opportunity to participate in the HIIT protocol. Those who wish to do this will follow the same protocol as the HIIT group outlined above. These participants will begin their intervention immediately following the one-month follow up PTSD checklist. This means that no matter what group you are randomized into you will have an opportunity to complete the HIIT protocol.

Risks

There are some potential risks to you by participating in this research. These include fatigue, a low risk of injury, and muscle soreness. Participants will experience elevated heart rates, increased blood pressure, and some general discomfort associated with high intensity exercise.

To prevent or to manage these risks the following steps will be taken:

All testing will be directed and supervised by Jake Bryan

You will be familiarized with the protocols ahead of the sessions in order to minimize potential discomfort and any risk of injury. All methods will be explained and demonstrated in full prior to each session.

Jake Bryan will be viewing all sessions, if any injury or discomfort is experienced by a participant, the research team will take the necessary steps outlined in University of Victoria protocols in response to the situation.

Voluntary Participation

Your participation and involvement in this research must be completely voluntary. Should you choose to participate, and later change your mind, you can withdraw at any time without judgment or personal repercussion. If you chose to withdraw, all data collected to date will be destroyed.

Initial informed consent will be obtained through the collection of signed consent forms (this document) and when you check in at the beginning of each session, you are consenting to participating in the session to follow.

Participation Restriction

You may be excluded from participation in the study if you have sustained an injury that may prevent safe exercise. Dr. Timothy Black is a member of the research team. Dr. Black has worked in the PTSD Veteran community extensively over the last few decades and it is possible that some participants will know him. We would ask that any participant who is doing this study as a favor to Dr. Black not participate in the study. However, if you know Dr. Black and still wants to participate in the study because you are interested in the research, you are permitted to participate. You have the option to end participation in the study at any point.

Unfortunately, due to the nature of the study consisting of physical activity and group sessions, if you are currently under uncontrolled PTSD crisis, we ask that you not participate in the study and encourage you to immediately contact a local resource center to assist you. The phone numbers and locations of several local resources are listed below, should you need them.

Men's Trauma Center
Location: 102-1022 Pandora Avenue, Victoria BC
Phone number: (250) 381-6367
Victoria Sexual Assault Center
Location: 201-3060 Cedar Hill Road, Victoria BC
Phone number: (250) 383-5545
Island Health USTAT
Location: 1250 Quadra Street, Victoria BC
Phone number: (250) 519-3544
Victoria Mental Health Center
Location: 2328 Trent Street, Victoria BC
Phone number: (250) 370-8175

Benefits

You will gain greater knowledge of HIIT and the benefits it can have on human physiology and psychology, the exercise you will perform will allow you to gain further knowledge of your own personal physical capability, and you will have the opportunity to participate in a formal academic research project.

Anonymity

As a participant completing all sessions of this research at home, your anonymity should be safe. Please be advised that information about you that is gathered for this research study uses an online program located in the United States or a program that can be accessed from the United States. As such, there is a possibility that information about you may be accessed without your knowledge or consent by the United States government in compliance with the United States Freedom Act. However, by using Zoom, which is the preferred application, you are able to input any name you wish as an identifier. No information gathered by the research team in this study will be shared with anyone. Also, no personal information or PTSD symptom information will be shared over Zoom to minimize potential risk. Zoom will only be used for observing and guiding purposes.

Confidentiality

Volunteers will be given a participant ID number protecting their identity throughout the testing protocol. During data collection video linked sessions, participants will not be referred to by name unless explicit permission is given to Jake Bryan to do so and if the individual, they may go by whatever single name they would like. Personal names will not be included on any data collection sheets or files Testing protocols will include no verbal announcement of results and data collection sheets will be kept in the possession of the research team. Your confidentiality, and the confidentiality of your data, will be protected by the use of this participant code, so that

your results will not be identifiable to anyone other than Jake Bryan and his supervisor. All paper data will be stored in a locked filing cabinet in McKinnon Building, room 171 in the School of Exercise Science, Physical and Health Education at UVIC and will have only participant codes identifying each participant. If you participate in the Breathing protocol and use the PTSD Coach Canada app, none of your personal data will be used by the app per the Terms and Conditions of PTSD Coach Canada.

Dissemination of Results

It is anticipated that the results of this study will be shared with others in the following ways: a written thesis, oral presentations, and published in a peer-reviewed academic journal. Upon completion, the written thesis will be made available publicly online via the university library. No individual results will be reported or published. As a participant, you will receive a report explaining the findings and your own personal individual results.

Disposal of Data

Data from this study will be disposed of within five years of study completion. Electronic data will be permanently erased, and paper copies will be shredded.

Contacts

Individuals that may be contacted regarding this study include:

a) Jake Bryan, Principal Investigator
Phone: 250-516-8352
Email: jkbryan@uvic.ca

b) Dr. Kathy Gaul, Supervisor
Phone: 250-721-8380
Email: kgaul@uvic.ca.

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your signature below indicates that you understand the above conditions of participation in this study, that you have had the opportunity to have your questions answered by the researchers, and that you consent to participate in this research project.

_____	_____	_____
Name of Participant	*Signature*	*Date*

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Appendix 5 Get Active Questionnaire (CSEP, 2021)

CSEP | SCPE
THE GOLD STANDARD IN EXERCISE SCIENCE AND PERSONAL TRAINING

Get Active Questionnaire

CANADIAN SOCIETY FOR EXERCISE PHYSIOLOGY –
PHYSICAL ACTIVITY TRAINING FOR HEALTH (CSEP-PATH®)

Physical activity improves your physical and mental health. Even small amounts of physical activity are good, and more is better.

For almost everyone, the benefits of physical activity far outweigh any risks. For some individuals, specific advice from a Qualified Exercise Professional (QEP – has post-secondary education in exercise sciences and an advanced certification in the area – see csep.ca/certifications) or health care provider is advisable. **This questionnaire is intended for all ages – to help move you along the path to becoming more physically active.**

☐ I am completing this questionnaire for myself.

☐ I am completing this questionnaire for my child/dependent as parent/guardian.

PREPARE TO BECOME MORE ACTIVE

The following questions will help to ensure that you have a safe physical activity experience. Please answer **YES** or **NO** to each question before you become more physically active. If you are unsure about any question, answer **YES**.

	YES	NO
1	Have you experienced **ANY** of the following (A to F) **within the past six months**?	
A	A diagnosis of/treatment for heart disease or stroke, or pain/discomfort/pressure in your chest during activities of daily living or during physical activity?	○
B	A diagnosis of/treatment for high blood pressure (BP), or a resting BP of 160/90 mmHg or higher?	○
C	Dizziness or lightheadedness during physical activity?	○
D	Shortness of breath at rest?	○
E	Loss of consciousness/fainting for any reason?	○
F	Concussion?	○
2	Do you currently have pain or swelling in any part of your body (such as from an injury, acute flare-up of arthritis, or back pain) that affects your ability to be physically active?	○
3	Has a health care provider told you that you should avoid or modify certain types of physical activity?	○
4	Do you have any other medical or physical condition (such as diabetes, cancer, osteoporosis, asthma, spinal cord injury) that may affect your ability to be physically active?	○

NO to all questions: go to Page 2 – ASSESS YOUR CURRENT PHYSICAL ACTIVITY

YES to any question: go to Reference Document – ADVICE ON WHAT TO DO IF YOU HAVE A YES RESPONSE

CSEP | SCPE
THE GOLD STANDARD IN EXERCISE SCIENCE AND PERSONAL TRAINING

Get Active Questionnaire

ASSESS YOUR CURRENT PHYSICAL ACTIVITY

Answer the following questions to assess how active you are now.

1 During a typical week, on how many days do you do moderate- to vigorous-intensity aerobic physical activity (such as brisk walking, cycling or jogging)? ☐ DAYS/WEEK

2 On days that you do at least moderate-intensity aerobic physical activity (e.g., brisk walking), for how many minutes do you do this activity? ☐ MINUTES/DAY

For adults, please multiply your average number of days/week by the average number of minutes/day: ☐ MINUTES/WEEK

Canadian 24-Hour Movement Guidelines recommend that adults accumulate at least 150 minutes of moderate- to vigorous-intensity physical activity per week. For children and youth, at least 60 minutes daily is recommended. Strengthening muscles and bones at least two times per week for adults, and three times per week for children and youth, is also recommended (see csep.ca/guidelines).

GENERAL ADVICE FOR BECOMING MORE ACTIVE

Increase your physical activity gradually so that you have a positive experience. Build physical activities that you enjoy into your day (e.g., take a walk with a friend, ride your bike to school or work) and reduce your sedentary behaviour (e.g., prolonged sitting).

If you want to do **vigorous-intensity physical activity** (i.e., physical activity at an intensity that makes it hard to carry on a conversation), and you do not meet minimum physical activity recommendations noted above, consult a Qualified Exercise Professional (QEP) beforehand. This can help ensure that your physical activity is safe and suitable for your circumstances.

Physical activity is also an important part of a healthy pregnancy.

Delay becoming more active if you are not feeling well because of a temporary illness.

DECLARATION

To the best of my knowledge, all of the information I have supplied on this questionnaire is correct.
If my health changes, I will complete this questionnaire again.

I answered NO to all questions on Page 1

Sign and date the Declaration below

I answered YES to any question on Page 1

Check the box below that applies to you:

☐ I have consulted a health care provider or Qualified Exercise Professional (QEP) who has recommended that I become more physically active.

☐ I am comfortable with becoming more physically active on my own without consulting a health care provider or QEP.

Name (+ Name of Parent/Guardian if applicable) [Please print]	Signature (or Signature of Parent/Guardian if applicable)	Date of Birth

Date	Email (optional)	Telephone (optional)

With planning and support you can enjoy the benefits of becoming more physically active. A QEP can help.

☐ Check this box if you would like to consult a QEP about becoming more physically active.
(This completed questionnaire will help the QEP get to know you and understand your needs.)

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THE GOLD STANDARD IN EXERCISE SCIENCE AND PERSONAL TRAINING

Get Active Questionnaire – Reference Document

ADVICE ON WHAT TO DO IF YOU HAVE A **YES** RESPONSE

Use this reference document if you answered **YES** to any question and you have not consulted a health care provider or Qualified Exercise Professional (QEP) about becoming more physically active.

1 Have you experienced ANY of the following (A to F) within the past six months?	
A A diagnosis of/treatment for heart disease or stroke, or pain/discomfort/pressure in your chest during activities of daily living or during physical activity? ☐ **YES**	Physical activity is likely to be beneficial. If you have been treated for heart disease but have not completed a cardiac rehabilitation program within the past 6 months, consult a doctor – a supervised cardiac rehabilitation program is strongly recommended. If you are resuming physical activity after more than 6 months of inactivity, begin slowly with light- to moderate-intensity physical activity. If you have pain/discomfort/pressure in your chest and it is new for you, talk to a doctor. Describe the symptom and what activities bring it on.
B A diagnosis of/treatment for high blood pressure (BP), or a resting BP of 160/90 mmHg or higher? ☐ **YES**	Physical activity is likely to be beneficial if you have been diagnosed and treated for high blood pressure (BP). If you are unsure of your resting BP, consult a health care provider or a Qualified Exercise Professional (QEP) to have it measured. If you are taking BP medication and your BP is under good control, regular physical activity is recommended as it may help to lower your BP. Your doctor should be aware of your physical activity level so your medication needs can be monitored. If your BP is 160/90 or higher, you should receive medical clearance and consult a QEP about safe and appropriate physical activity.
C Dizziness or lightheadedness during physical activity ☐ **YES**	There are several possible reasons for feeling this way and many are not worrisome. Before becoming more active, consult a health care provider to identify reasons and minimize risk. Until then, refrain from increasing the intensity of your physical activity.
D Shortness of breath at rest ☐ **YES**	If you have asthma and this is relieved with medication, light to moderate physical activity is safe. If your shortness of breath is not relieved with medication, consult a doctor.
E Loss of consciousness/fainting for any reason ☐ **YES**	Before becoming more active, consult a doctor to identify reasons and minimize risk. Once you are medically cleared, consult a Qualified Exercise Professional (QEP) about types of physical activity suitable for your condition.
F Concussion ☐ **YES**	A concussion is an injury to the brain that requires time to recover. Increasing physical activity while still experiencing symptoms may worsen your symptoms, lengthen your recovery, and increase your risk for another concussion. A health care provider will let you know when you can start becoming more physically active, and a Qualified Exercise Professional (QEP) can help get you started.

After reading the ADVICE for your YES response, go to Page 2 of the *Get Active Questionnaire* – ASSESS YOUR CURRENT PHYSICAL ACTIVITY

CSEP | SCPE
THE GOLD STANDARD IN EXERCISE SCIENCE AND PERSONAL TRAINING

Get Active Questionnaire – Reference Document

ADVICE ON WHAT TO DO IF YOU HAVE A **YES** RESPONSE

Use this reference document if you answered **YES** to any question and you have not consulted a health care provider or Qualified Exercise Professional (QEP) about becoming more physically active.

2 Do you currently have pain or swelling in any part of your body (such as from an injury, acute flare-up of arthritis, or back pain) that affects your ability to be physically active? ☐ YES

If this swelling or pain is new, consult a health care provider. Otherwise, keep joints healthy and reduce pain by moving your joints slowly and gently through the entire pain-free range of motion. If you have hip, knee or ankle pain, choose low-impact activities such as swimming or cycling. As the pain subsides, gradually resume your normal physical activities starting at a level lower than before the flare-up. Consult a Qualified Exercise Professional (QEP) in follow-up to help you become more active and prevent or minimize future pain.

3 Has a health care provider told you that you should avoid or modify certain types of physical activity? ☐ YES

Listen to the advice of your health care provider. A Qualified Exercise Professional (QEP) will ask you about any considerations and provide specific advice for physical activity that is safe and that takes your lifestyle and health care provider's advice into account.

4 Do you have any other medical or physical condition (such as diabetes, cancer, osteoporosis, asthma, spinal cord injury) that may affect your ability to be physically active? ☐ YES

Some people may worry if they have a medical or physical condition that physical activity might be unsafe. In fact, regular physical activity can help to manage and improve many conditions. Physical activity can also reduce the risk of complications. A Qualified Exercise Professional (QEP) can help with specific advice for physical activity that is safe and that takes your medical history and lifestyle into account.

After reading the ADVICE for your YES response, go to Page 2 of the *Get Active Questionnaire* – ASSESS YOUR CURRENT PHYSICAL ACTIVITY

WANT ADDITIONAL INFORMATION ON BECOMING MORE PHYSICALLY ACTIVE?

- **csep.ca/certifications**
  CSEP Certified members can help you with your physical activity goals.
- **csep.ca/guidelines**
  Canadian Physical Activity Guidelines for all ages.

Appendix 6 Tabata Protocol

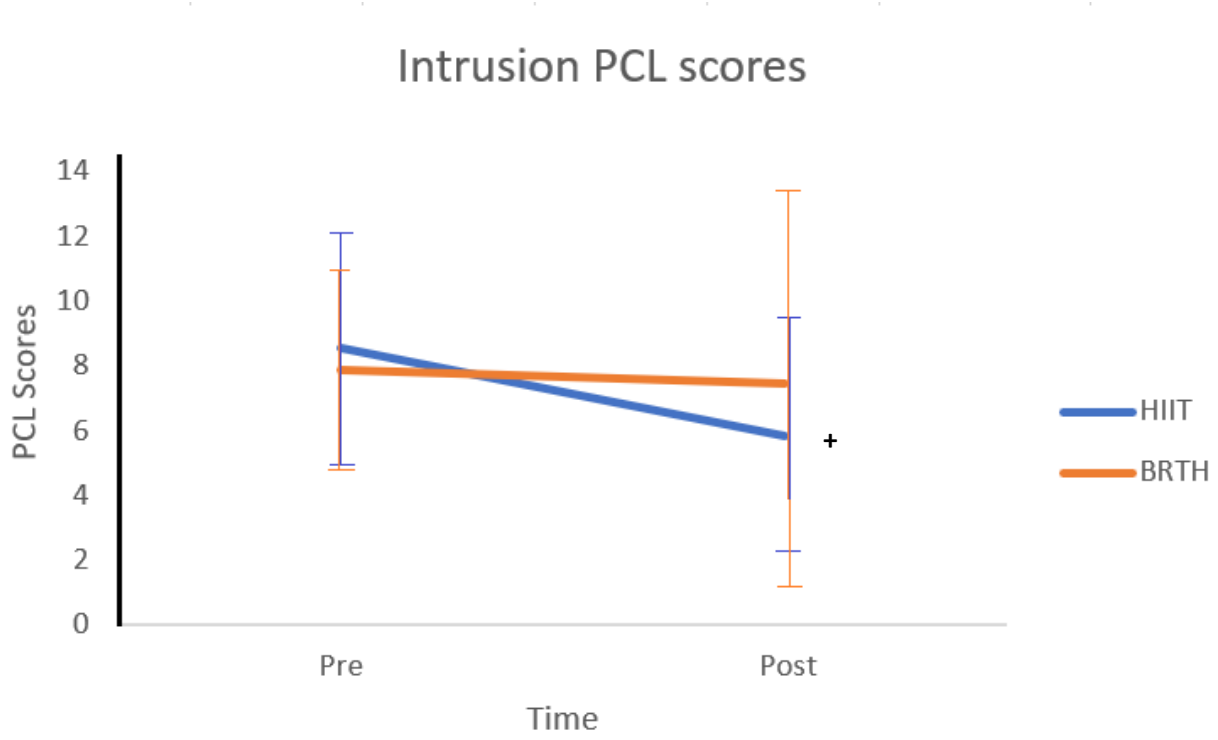
HIIT = 1st exercise (4 sets)

HIIT = 2nd exercise (4 sets)

Appendix 7 PCL Statistical Analysis

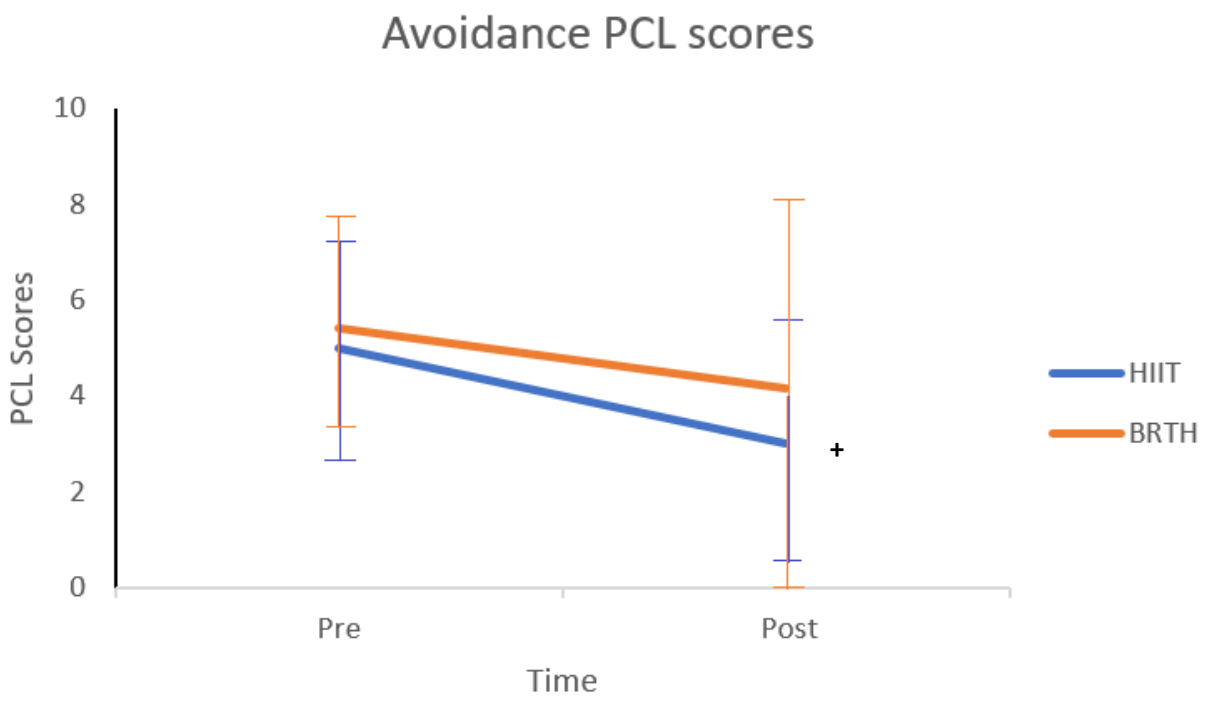
In the Intrusion subscale there were statistically significant reductions between the pre-test and post-test scores following the HIIT intervention only (Figure A7.1). Similarly following the HIIT intervention, the Avoidance subscale scores were significantly reduced compared with pre-test scores (Figure A7.2). No BRTH intervention-induced changes in any of the PCL subscales were found.

Figure A7.1 Mean (SD) PTSD Checklist (PCL) Intrusion subscale scores (n=7)



+ significant difference between pre-test and post-test scores in HIIT intervention

Figure A7.2 Mean (SD) PTSD Checklist (PCL) Avoidance subscale scores (n=7)



+ significant difference between pre-test and post-test scores in HIIT intervention

All participants demonstrated a reduction in Intrusion PCL scores (Figure A7.3) and Avoidance (Figure A7.4) following the HIIT intervention. While only three participants demonstrated a reduction in Intrusion PCL scores following the BRTH intervention (Figure A7.5) and only two participants demonstrated a reduction in Avoidance PCL scores following the BRTH intervention (Figure A7.6).

Figure A7.3 PTSD Checklist (PCL) subscale Intrusion scores for each participant before (pre-test) and after (post-test) the HIIT intervention

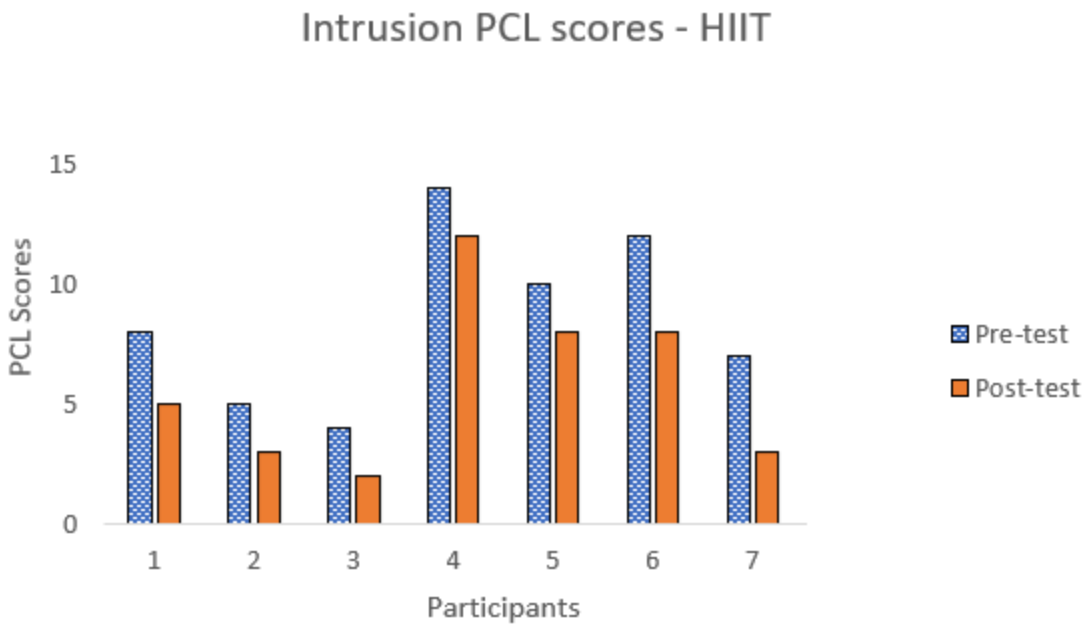


Figure A7.4 PTSD Checklist (PCL) subscale Avoidance scores for each participant before (pre-test) and after (post-test) the HIIT intervention

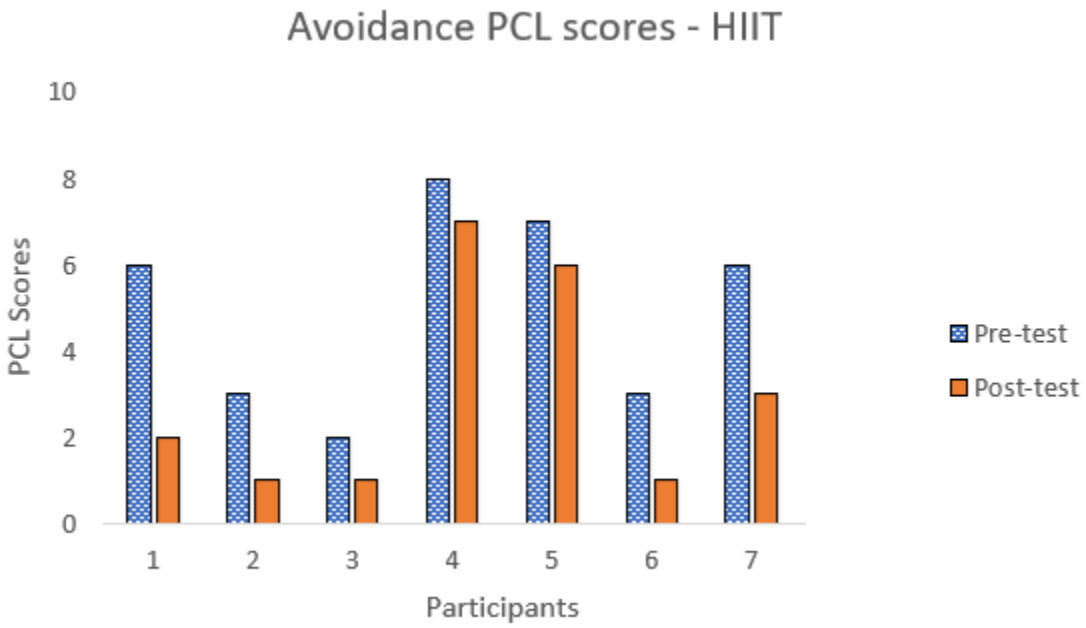


Figure A7.5 PTSD Checklist (PCL) subscale Intrusion scores for each participant before (pre-test) and after (post-test) the BRTH intervention

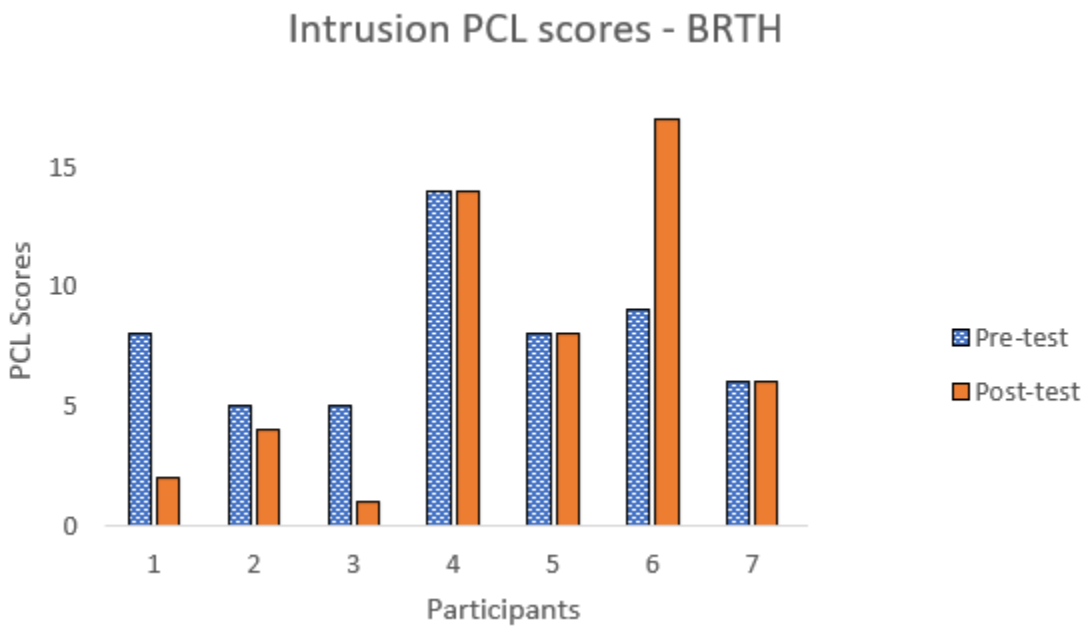
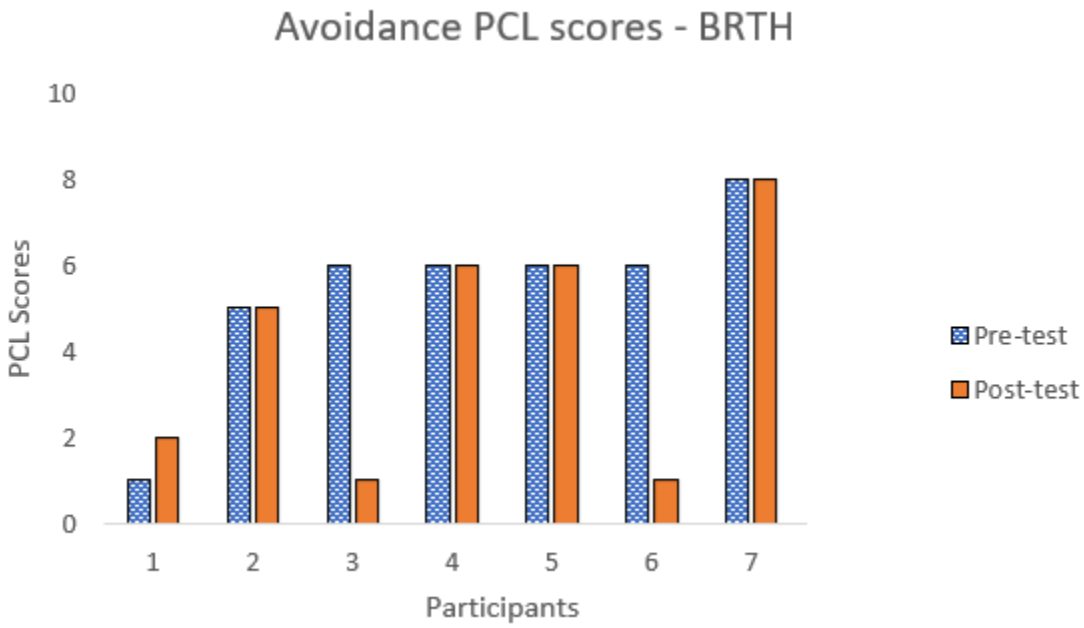
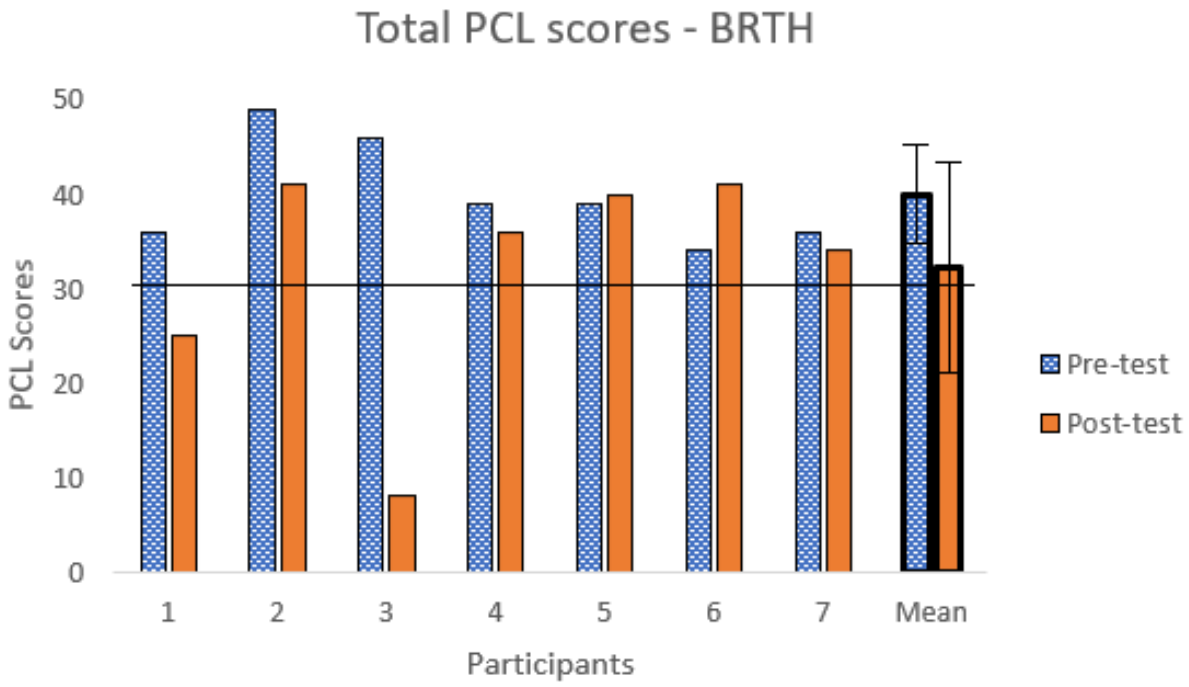


Figure A7.6 PTSD Checklist (PCL) subscale Avoidance scores for each participant before (pre-test) and after (post-test) the BRTH intervention



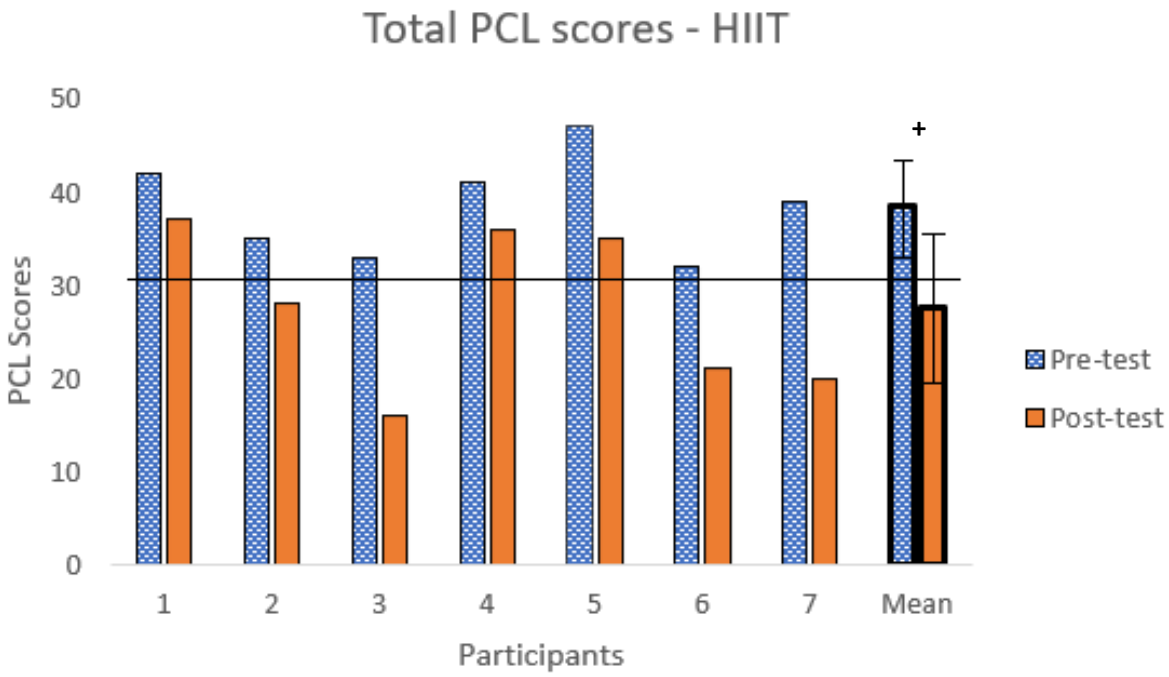
Five participants in the BRTH intervention demonstrated a reduction in Total PCL score post intervention (Figure A7.7). After the HIIT intervention, all participants experienced a reduction in Total PCL scores (Figure A7.8).

Figure A7.7 PTSD Checklist (PCL) scores for each participant and group mean (SD) pre- and post-test in the BRTH intervention



Note: horizontal black line indicates the predicted PTSD cut-off score (31)

Figure A7.8 PTSD Checklist (PCL) scores for each participant and group mean (SD) pre-test and post-test in the HIIT intervention



Note: horizontal black line indicates the predicted PTSD cut-off score (31)

+ Significant difference between pre-test and post-test scores