Evaluation of an Online Cognitive Behavioural Therapy, Mindfulness Meditation, and Yoga (CBT-MY) Intervention for Posttraumatic Stress Disorder: A Single Arm Clinical Trial with Psychometric and Psychophysiological Outcomes

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Abstract

Objective: The aim of this dissertation was to evaluate an online cognitive behavioural therapy intervention that combined mindfulness and yoga (CBT-MY) in the treatment of posttraumatic stress disorder (PTSD). A secondary objective was to explore objective measures of autonomic function among adults with PTSD. **Methodology:** This single-arm experimental trial was conducted at York University. A total of 22 adults with PTSD symptoms were recruited to complete an 8-week intervention consisting of weekly CBT-MY material and one hour of virtual, phone-based CBT counselling each week. Psychometric outcomes of PTSD, depression, anxiety, chronic pain, and mindfulness were collected a two time points (baseline, post-intervention). Objective measures of pupillometry and heart rate variability (HRV) were examined during a 25-minute protocol consisting of rest, a stress task, and guided meditation. Psychophysiology outcomes of PTSD participants were compared with cross-sectional data from a convenience cohort of 49 non-PTSD-affected control participants that completed the computer protocol at a single time point and did not receive the intervention. **Results.** Pre-post analyses revealed large reductions in PTSD symptom severity (d = 1.60), depression (d = 0.83), anxiety (d = 0.99), and increased mindfulness (d = 0.88). Linear mixed effects modelling revealed a significant main effect of time with reductions in peak pupil dilation (PPD) post-intervention ($\Delta M = -.06$, SE = .01, p = .001) but no significant change in pre-post HRV (p = .87). Significantly lower HRV in PTSD subjects was observed compared to non-PTSD participants ($F_{1,65} = 14.54$, p = .001, η^2 = .10). **Conclusion.** 8-weeks of online CBT-MY with weekly phone-based counselling shows promise in the reduction of PTSD symptom severity and associated mental health outcomes beyond clinically meaningful ranges. Autonomic function was less clear and supported improved pupillometry response. Findings lend support for future randomized trials investigating integrated online CBT-MY treatment in reducing PTSD symptom severity.

Dedication

This dissertation and my entire PhD journey are dedicated to my cherished husband, Brandon.

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List of Abbreviations

ANS – Autonomic Nervous System

BAI – Beck Anxiety Inventory

BDI – Beck Depression Inventory

BPI – Brief Pain Inventory

CAN – Central Autonomic Network

CAPS-5 – Clinician Administered Posttraumatic Stress Interview for *DSM-5*

CBT – Cognitive Behavioural Therapy

CBT-MY – Cognitive Behavioural Therapy + Mindfulness + Yoga

CNS – Central Nervous System

DMNV – Dorsal Motor Nucleus of the Vagus

DSM – Diagnostic and Statistical Manual for Mental Health Disorders

DVC – Dorsal Vagal Complex

ECG – Electrocardiography

EEG - Electroencephalogram

ENS – Enteric Nervous System

FFMQ – Five Facet Mindfulness Questionnaire

HF HRV – High Frequency Heart Rate Variability

HRV – Heart Rate Variability

LME – Linear Mixed Effects

LF HRV – Low Frequency Heart Rate Variability

MCID – Minimal Clinically Important Difference

NIM – Neurovisceral Integration Model

PCL – PTSD Checklist *DSM*-5

PCS – Pain Catastrophizing Scale

PFC – Prefrontal Cortex

PNS – Parasympathetic Nervous System

PPD – Peak Pupil Dilation

PTSD – Posttraumatic Stress Disorder

PVT – Polyvagal Theory

RCT – Randomized Controlled Trial

RSA – Respiratory Sinus Arrythmia

SA – Sinoatrial

SES – Socioeconomic Status

SNS – Sympathetic Nervous System

VVC – Ventral Vagal Complex

Chapter 1: Introduction

Traumatized people chronically feel unsafe inside their bodies: The past is alive in the form of gnawing interior discomfort. Their bodies are constantly bombarded by visceral warning signs, and, in an attempt to control these processes, they often become expert at ignoring their gut feelings and in numbing awareness of what is played out inside. They learn to hide from their selves.

- Dr. Bessel van der Kolk, The Body Keeps the Score

This dissertation represents over 5 years of clinical research, intervention design, and therapeutic work with an underrepresented sample of trauma survivors with various histories of sexual, physical, and childhood trauma. Chapter 1 introduces the topic, describes the evolution of the clinical diagnostic criteria for posttraumatic stress disorder (PTSD), and summarizes the current state of PTSD in Canada. In Chapter 1, the population studied in this dissertation, young adults ages 18-35 years with PTSD, is introduced and includes an overview of the barriers and facilitators of accessing clinical treatment among this target population. This chapter concludes by outlining the study purpose and rationale for the study.

Within this dissertation, five more chapters follow. Chapter 2 provides a comprehensive review of the literature on the psychophysiology mechanism of the trauma response and introduces the polyvagal theory and neurovisceral integration model as the guiding frameworks for this dissertation. Chapter 2 also explores two markers of autonomic function, pupillometry and heart rate variability (HRV), and the relevance to PTSD symptom detection and treatment. The applicability of mindfulness and yoga as an adjunct to traditional psychotherapy is reviewed and an overview of the utility of online treatment delivery for clinical mental health disorders is reviewed in Chapter 2. Chapter 3 presents the research methodology and specific details of how the clinical trial was executed. The analysis and findings of the research are summarized in Chapter 4. In Chapter 5, an in-depth interpretation of the results and whether hypotheses were confirmed or disconfirmed are presented; the dissertation concludes with a discussion of the

clinical and research implications of the findings, recommendations for future research in this field, and concluding remarks. Ultimately, the intention of this entire dissertation was about validating the lived experience of survivors who often get missed in diagnostic criteria and identifying the universal commonalities between people who have endured trauma on a wide spectrum in the hopes to advance the field of trauma and PTSD treatment.

The Definition of Trauma

The experience of trauma, including single, multiple, or chronic repetitive exposures, imprints on the brain and body. Historical atrocities involving war (e.g., Vietnam War) or genocide (e.g., Holocaust, Rwanda), and sexual abuse have largely shaped our understanding of traumatic experiences and associated symptoms. Nonetheless, in the field of trauma research, there still remains an active debate about the identification and quantification of exposure events considered sufficiently traumatizing to warrant clinical treatment. In North America, the most widely adopted definition of trauma comes from the American Psychiatric Association (2013) *Diagnostic and Statistical Manual for Mental Health Disorders, Fifth Edition (DSM-5)* and refers to trauma as:

> Exposure to actual or threatened death, serious injury, or sexual violence in one (or more) of the following ways: directly experiencing the traumatic event(s), witnessing, in person, the event(s) as it occurred to others, learning that the traumatic event(s) occurred to a close family member or close friend […], or experiencing repeated or extreme exposure to aversive details of the traumatic event(s). (p. 271)

While this definition provides a reference point, there remains the possibility that, under the current definition, a large number of individuals who struggle with traumatic memories and associated symptoms are mislabeled or overlooked since their lived experiences do not fit within

the current APA definition. For example, less obvious traumas such as repeated micro-aggressions, bullying, verbal harassment, xenophobia, racism, invasive medical procedures, birth stress, or the immigration process may be deeply traumatizing for some people. However, these experiences do not fully meet the *DSM-5* definition of trauma exposure. As a result, a potentially large number of traumatic instances may be understudied within trauma-related research. Thus, a primary aim of this dissertation is to understand trauma exposure among an underrepresented population.

Furthermore, academics and clinicians have yet to reach a final consensus on a precise definition of trauma. A psychophysiological approach examining the objective, predictable, and involuntary changes to the brain and body that result from traumatic exposure *of any kind* may be a more accurate approach to better understand and effectively treat trauma-related disorders, including PTSD. Thus, an approach to trauma that is grounded in neurobiology and psychophysiology, can help us better understand the impact of trauma through a lens that focuses on the mechanism of the trauma response and not necessarily the exposure (Levine & Frederick, 1997). Accordingly, this dissertation aims to understand trauma from an objective perspective throughout all research phases.

Overview of the Clinical Diagnostic Criteria for PTSD

The American Psychiatric Association (APA) is considered the leading North American organization in establishing the definitions and classifications of mental health disorders which are compiled in the *DSM-5.* In relation to PTSD, ever since its introduction and initial iteration within the third edition of the *DSM* in the 1980s, there has been controversy and debate over its conceptualization and definition (APA, 2020; Pai et al., 2017). The original motivation for establishing a clinical diagnosis of PTSD was aimed at diagnosing American soldiers,

predominantly male, returning from the Vietnam war who presented with symptoms that were not classifiable (Pai et al., 2017). There have been four revisions to the *DSM* PTSD diagnostic criteria within *DSM-III*-R (1987), *DSM-IV* (1994), *DSM-IV*-TR (2000), and the *DSM-5* (2013) editions, highlighting the complexity of establishing a standardized and widely accepted definition of PTSD that is applicable to multiple populations. The current *DSM-5* no longer classifies PTSD as a severe anxiety disorder (APA, 2013; Svenaeus, 2014). Instead, PTSD is now classified as a *trauma- and stressor-related disorder* (APA, 2013, 2000) given the evidence that PTSD requires trauma exposure and involves multiple symptoms and emotions (e.g., dissociation, shame, guilt) that are not solely anxiety-based (Pai et al., 2017). Updated revisions to the PTSD clinical symptom subscales in the *DSM-5* include an increase in the number of symptom groups (from 3 to 4 symptom subscales) and the number of symptoms (from 17 to 20 symptoms) that must persist for at least one month prior to PTSD being diagnosed (APA, 2013).

Clinical Assessment and Diagnosis of PTSD

Currently, diagnosing PTSD is first established by satisfying *Criterion A* which requires exposure to a traumatic event that results in death (actual or the threat of), serious bodily injury (actual or the threat of), or sexual violence (actual or the threat of) that may be experienced directly, witnessed, learned about (i.e., close family member), or as part of professional duties (i.e., first responder; APA, 2013). Once *Criterion A* is satisfied, a clinical assessment of PTSD symptoms is conducted. If an individual does not satisfy the criteria for trauma exposure outlined in the *DSM* (i.e., *Criterion A*), the individual does not qualify as having PTSD.

Table 1 summarizes each of the *DSM-5* PTSD symptom subscales including *Criterion B: Intrusion* (i.e., flashbacks, nightmares), *Criterion C: Avoidance* (i.e., avoidance of thoughts or external reminders), *Criterion D: Negative alterations in cognition and mood* (i.e., self-blame,

unworthiness), and *Criterion E: Alterations in arousal and reactivity* (i.e., insomnia, anxiety, hypervigilance; APA, 2013; Pai et al., 2017; Svenaeus, 2014).

Table 1

DSM-5 Clinical Diagnostic Criteria for PTSD

DSM-5 **Criterion**	**Symptom Description**
Criterion A: Trauma Exposure *Must be established prior to clinical assessment	"Actual or threatened death, serious bodily injury, or actual or threatened sexual violence" via any of the following: 1. Direct exposure 2. Witnessed in-person others directly exposed to trauma 3. Learning of direct exposure of trauma of a close family member or friend 4. Repeated or extreme exposure to aversive details of traumatic event(s) (e.g., first responders collecting human remains) in-person or via work-related exposure
If Criterion A is satisfied PTSD clinical assessment proceeds	
Criterion B: Intrusion Symptoms (≥ *1 "moderate" symptom clearly present required for diagnosis)*	1. Recurrent, involuntary, and intrusive distressing memories of the traumatic event(s) 2. Recurrent distressing trauma-related dreams 3. Dissociative reactions/flashbacks related to the trauma 4. Intense of prolonged psychological distress to internal/external reminders of the traumatic event 5. Marked physiological reaction to internal/external trauma-related reminders
Criterion C: Persistent Avoidance (≥ *1 "moderate" symptom clearly present required for diagnosis)*	1. Avoidance/efforts to avoid distressing internal trauma-related memories, thoughts, or feelings 2. Avoidance/efforts to avoid external trauma-related reminders (e.g., people, places, objects, conversations)
Criterion D: Negative Cognition and Mood (≥ *2 "moderate" symptoms clearly present required for diagnosis)*	1. Amnesia surrounding trauma exposure 2. Persistent and exaggerated negative beliefs about self, others, or the world 3. Persistent, distorted trauma-related cognitions linked to inappropriate blame of self/others 4. Persistent negative emotions (e.g., fear, horror, shame)

	5. Loss of interest or participation in significant activities 6. Detachment or estrangement from others 7. Persistent inability to experience positive emotions (e.g., happiness, satisfaction)
Criterion E: Arousal and Reactivity (*≥ 2 "moderate" symptoms clearly present required for diagnosis)*	1. Irritability and angry outbursts with little/no provocation 2. Reckless or self-destructive behaviour 3. Hypervigilance 4. Exaggerated startle response 5. Difficulties with concentration 6. Sleep disturbance (e.g., difficulty falling or staying asleep or restless sleep)
Additional Criteria	
Criterion F: Duration of Symptoms	• ≥ 1 month
Criterion G: Distress or Impairment (*≥ 1 "moderate" symptom clearly present required for diagnosis)*	• Clinically significant distress; impairment in social, occupational and other functioning
Criterion H: Not Attributable to Another Disorder	• Symptoms are independent of physiological effects of a substance (e.g., meditation, alcohol) or another medical condition
Dissociative Symptoms *(≥ 1 for subtype)*	1. Depersonalization 2. Derealization
Delayed Onset	• ≥ 6 months
Clinical PTSD Diagnosis	• **All criteria (A-G) met**

Challenges with the DSM-5 PTSD Clinical Diagnostic Criteria

While attempts have been made to refine the PTSD diagnostic criteria, the *DSM-5* remains largely descriptive and symptom-based, and still does not fully consider other nuanced factors that influence the personal experience of trauma. These may include repeated early childhood trauma exposure, gender, ethnicity, and lifestyle influences. The *DSM-5* was revised to exclude the subjective response of the index trauma causing "intense fear, horror, or helplessness" previously prominent in the *DSM-IV* as an attempt to provide a more objectively-based diagnostic criteria. Once *Criterion A* is established, the individual is instructed to identify the worst *single-index* traumatic event to be used as the referent to guide the PTSD clinical

diagnostic assessment (APA, 2013). Based on this, multiple trauma exposures, such as repeated developmental trauma (e.g., childhood neglect or abuse), or complex trauma exposures such as historical trauma (e.g., racialized trauma), psychosocial trauma (e.g., verbal harassment, divorce) and those that do not involve an immediate threat to life (e.g., cancer diagnosis), are not taken into consideration when conducting the clinical assessment regardless of how stressful or severe the events were experienced by the individual. The requirement to satisfy *Criterion A* may not be reflective of the varied lived experiences of marginalized individuals at-risk for PTSD who experience chronic exposure or fear of trauma exposure based on sociodemographic factors such as race, ethnicity, and childhood trauma exposure (Pai et al., 2017; Sedlak et al., 2010).

Notably, a comparison study of *DSM-IV* versus *DSM-5* conducted by Kilpatrick et al.(2013) found that 60% of the trauma-exposed sample assessed for PTSD and met the *DSM-IV* criteria did not meet the revised *DSM-5* criteria due to changes to *Criterion A* (Kilpatrick et al., 2013). These are not trivial or minor shifts. If the updated *DSM-5* criterion changes are considered more conservative than *DSM-IV*, this may result in a significant proportion of individuals who identify as being traumatized with PTSD symptoms, not receiving necessary treatments to alleviate symptoms due to the more conservative diagnostic revisions. Less widely accepted trauma exposures, unrelated to military veterans and sexual assault victims, such as repeated developmental trauma in childhood, xenophobia and racism, radical medical procedures, long-term civil conflict or displacement, and the process of immigration (after tolerating adverse living conditions) may be important diagnostic criteria for the understanding and treatment of PTSD (World Health Organization, 2017).

Subsyndromal PTSD

Another issue in the *DSM-5* clinical diagnostic criteria of PTSD is the determination of a diagnostic threshold and clinical relevance of subsyndromal or "partial" PTSD. Subthreshold PTSD refers to individuals who do not meet full PTSD diagnostic criteria, especially for both avoidance and hyperarousal symptom criteria, but present with several other PTSD symptoms (Cukor et al., 2010; Katz et al., 2014; Stein et al., 1997). Prevalence of subsyndromal PTSD has been reported in the literature and varies widely with ranges from 3.7% in a representative community sample (Cukor et al., 2010; Stein et al., 1997) to 44% among motor vehicle accident survivors (Cukor et al., 2010; Blanchard et al., 1994). Rates must be interpreted with caution given the lack of uniform definition of subsyndromal PTSD. Current *DSM-5* PTSD diagnostic criteria requires that an individual experience at least "moderate" severity for one intrusion symptom in Criterion B, one avoidance symptom in Criterion C, at least two negative cognition and mood symptoms in Criterion D, and at least two arousal and reactivity symptoms in Criterion E (See Table 1; APA, 2013). Based on the conceptualization of subsyndromal PTSD, an individual who meets each of the seven symptom criteria for Criterion D, but fails to meet one of two symptoms in Criterion C, would not be diagnosed with PTSD. As a result, a potentially large portion of the population who experience significant distress and functional impairment comparable to those with full PTSD, but do not meet the full diagnostic criteria for PTSD, may be missed with the current diagnostic criteria.

Comparison of PTSD Classification Systems

Although the *DSM-5* is considered as the leading diagnostic "Bible" in North America, it is not as popular in other areas of the world. The *International Classification of Diseases* (*ICD*) is another diagnostic system that sets forth diagnostic criteria for PTSD and is more widely used

in European countries. While a full critique of the *ICD* is beyond the scope of this dissertation, the two latest *ICD* diagnostic criteria (*ICD-10, ICD-11*) have been found to be less strict in diagnostic criteria when compared to the *DSM-IV* and *DSM-5* (Stein et al., 2014). Stein et al. (2014) conducted a large-scale cross-national study that examined the implications of differing PTSD diagnostic criteria found in the two most recent editions of the *DSM* (*DSM-IV, DSM-5*) and the *ICD* (*ICD-10, ICD-11*). This study, involving fully-structured face-to-face interviews with 23,936 respondents across 13 countries with self-reported trauma exposure, found that overall, a total of 5.6% of respondents met criteria for PTSD in at least one of the four classification systems, with the highest prevalence found in the *ICD-10* (4.4%) and the lowest in the *DSM-5* (3.0%; Stein et al., 2014). Across the PTSD diagnostic systems, only 1.8% of all respondents met PTSD criteria in all four systems and indicated the most conservative approach to PTSD diagnosis was in the *DSM-5* (Stein et al., 2014). Although methodological challenges and retrospective recall of lifetime trauma exposure may yield possible bias and limit the results, these findings do point towards the inconsistencies of diagnostic systems in the assessment of PTSD and the potential to overlook individuals who suffer from clinically relevant symptoms that are at present not considered within various diagnostic criteria (Stein et al., 2014).

Overview of Posttraumatic Stress Disorder in Canada

Globally, approximately 10-37% of people exposed to a traumatic event will experience persistent symptoms (e.g., lasting one month or longer) reflecting PTSD (Breslau et al., 1998; Santiago et al., 2013). In Canada, PTSD is a growing public health concern as the Canadian population ranks amongst the highest in PTSD prevalence worldwide at an estimated 9.2% or ~3.7 million people (Dückers et al., 2016; Van Ameringen et al., 2008). Among 24 countries examined, the heightened prevalence of PTSD in Canada is considered paradoxical and more

than three times higher than in countries with a higher vulnerability index (e.g., social and economic deprivation) and susceptibility to trauma exposure and sustained harm (e.g., Nigeria, Mexico, Columbia; Dückers et al., 2016). Methodological challenges such as cross-sectional data, language barriers, and demographic or cultural factors may hinder direct comparison of prevalence rates across multiple countries. However, these findings suggest that populations of less vulnerable countries, with more access to services, resources and healthcare, may have a greater likelihood of developing PTSD in their lifetime (Dückers et al., 2016). Reasons for this paradox remain speculative and unsubstantiated in the literature and warrant continued exploration among representative community samples.

Based on a 2002 nationally representative community sample of 2,991 individuals living in Canada, the majority of Canadian adults (76.1%) report at least one traumatic exposure (e.g., sexual assault) significant enough to lead to PTSD, with the majority reporting exposure to multiple traumatic events (Van Ameringen et al., 2008). Men report significantly higher numbers of traumatic exposures (M = 2.48 events; SD = 2.43) compared to women (M = 2.15 events; SD = 2.23; Van Ameringen et al., 2008). However, women were significantly more likely than men to meet criteria for full or partial/subsyndromal PTSD (Van Ameringen et al., 2008). PTSD was not found to be linked to socioeconomic status; distribution of PTSD prevalence rates was equal across all education levels, income strata, and employment status (Van Ameringen et al., 2008). This epidemiological study conducted by Van Ameringen et al. (2008) remains the last known research evaluation to understand PTSD prevalence in Canada, highlighting the need for updated research on PTSD and its risk factors.

Economic Burden of PTSD

The economic burden specifically attributed to PTSD in Canada is unknown, likely due to the overlap with co-morbid conditions of depression and anxiety. Economic costs associated with treating *all* mental health disorders are represented in direct (e.g., pharmacotherapy, psychiatry) and indirect (e.g., chronic disability, reduced quality of life) health-related costs. The current global economic burden of all mental illness combined, is estimated at $2.5 trillion (2010), and is projected to increase exponentially to $6 trillion (2030), establishing diagnosable psychiatric disorders as the costliest among non-communicable diseases worldwide (Bloom et al., 2012; Whiteford et al., 2013; World Health Organization, 2008). Within a North American context, more than 20% of adults carry psychiatric diagnoses (e.g., PTSD) and receive pharmacological prescriptions for mental health disorders (Centers for Disease Control and Protection [CDCP], 2011; Medco Health Solutions Inc, 2011; Smetanin et al., 2011). In Canada, the economic cost of mental illness is estimated at ~$50 billion annually, with $42.3 billion in direct costs to the healthcare system (Smetanin et al., 2011). Given the complexity of symptoms present with PTSD, there is a greater likelihood that the diagnosis often gets missed or mislabeled leading to additional healthcare service costs (Kessler, 2000). Targeted interventions addressing the most at-risk populations for PTSD are an urgent priority and improvements in care provision could result in significant cost-savings.

Young Adulthood, Life Transitions and Mental Health

As of 2018, Canadian young adults, defined by Statistics Canada as ages 15-29 years, represented a substantial portion (19.2%; ~7.2 million) of the entire national population (Statistics Canada, 2019). Of these, 27% (~2 million) identified as a visible minority, with 76%

of the Canadian young adults in the Greater Toronto Area reporting being first generation Canadians (Statistics Canada, 2019). Not surprisingly, a large number of young adults (57%; 3.6 million) are continuing to live with parents for longer durations than before, with the greatest increase seen among young adults ages 27-30 years; at this age, 22% are living with their parents (Statistics Canada, 2019). The socio-economic factors associated with longer transitions to adulthood include living with parents longer, attending school for more years (than parents), and increasing age at time of marriage and parenthood (Clark, 2014). Compared to a 1971 cohort of young adults, the number of women who attend post-secondary education has risen from 7% (1971) to 29% in 2001 (Clark, 2014) and substantially greater number of young adults are entering post-secondary education than before (25% in 1971 vs. 48% in 2001). Among those who complete graduate or professional degrees, the median age at time of completion ranges from 29 (Master's degree) to 33 (MD, PhD) which further postpones other life transitions such as initiating marriage and parenthood (Clark, 2014).

Young adulthood is a distinct and complex life stage characterized by significant life-transitions (e.g., leaving home, entering post-secondary education, parenthood) which have the potential to exacerbate ongoing mental health problems (Arnett, 2000; Baranowski et al., 1997; Bellows-Riecken & Rhodes, 2008; Bray & Born, 2004). Over 70% of all mental health problems are linked to early onset experiences during childhood and adolescence, and among Canadian adults, younger adults are the most vulnerable age group for diagnosable mental health conditions, substance abuse, and suicide (Arnett, 2000; Lunau, 2012; Public Health Agency of Canada, 2006). Young adulthood also represents an opportune time for treatment intervention since the health-promoting habitual behaviour patterns established at this stage may extend across the lifespan into adulthood and older-adulthood.

Unique to young adulthood is the process of forming a unique personal identity, independent of parents (Arnett, 2000; Marini, 1985). Key transitions during young adulthood include separating from dependencies (e.g., parents/guardians) for financial, residential, and emotional needs, and transitioning to independent living, post-secondary education, full-time work, and cohabitation with a partner, marriage, and parenthood (Arnett, 2000; Marini, 1985). In addition to these developmental milestones, Arnett (2000) has identified five dimensions that characterize young adulthood including *identity exploration, instability, feeling in-between, possibilities and self-focus*. Identity exploration during young adulthood pertains to the increased freedom and possibility to explore various life paths before making the long-term commitments of an adult identity (Arnett, 2000, 2001). For many young adults, this increased freedom is a time for self-focus on one's desires, needs and wants (independent of parents), and often comes with an intense phase of instability as a result of navigating various short-term work, school and housing commitments (Arnett, 2000, 2001).

During young adulthood, there is often a feeling of being "in-between" adolescence and adulthood since individuals have not yet had the time to accept full responsibility for themselves and become financially independent, yet they are still making more personal lifestyle decisions than during adolescence (Arnett, 2000). For a typical young adult, this time-period of life may be characterized as exciting *and* stressful. For young adults who have experienced trauma, this stressful time-period may be rendered more stressful due to intense and even overwhelming symptoms. A number of strategies to navigate these life-transitions exist and contrast with developmental or mental health difficulties. These can be broadly classified as health *promoting* (e.g., physical activity, stress-reduction techniques; Allender et al., 2008; Baranowski et al., 1997; Bray & Born, 2004) versus health *harming* (e.g., substance use, avoidance).

There is evidence suggesting that health promoting behaviours (e.g., exercise, nutrition) tend to generally decline at the onset of a life-transition (Allender et al., 2008), particularly during the transitions to post-secondary education (Bray & Born, 2004) and parenthood (Bellows-Riecken & Rhodes, 2008). The compounded effect of unresolved trauma combined with the navigation of complex life-transitions may lead to an increased risk of maladaptive health harming behaviours, and a retriggering of trauma-related symptoms. Sixty percent of young adults (~4.3 million) report having experienced a mood disorder in the last year, yet only 53% sought professional help (Statistics Canada, 2019). Taken together, these data suggest that young adulthood may be critical time-period for targeted mental health intervention efforts.

Childhood Trauma Exposure in Canada

One possible explanation for the disproportionate mental health challenges experienced during young adulthood may be the presence of unresolved or untreated childhood exposure to maltreatment and trauma, such as physical and sexual abuse (Felitti et al., 1998). The World Health Organization (2010) defines childhood maltreatment as any form of abuse and neglect that occurs to children under 18 years of age and includes all types of physical and/or emotional ill-treatment, sexual abuse, neglect, negligence and commercial or other exploitation. Research examining the prevalence and nature of childhood trauma exposure presents many challenges based on the limitations of accurate reporting by victims. These include underreporting due to a fear of consequences, stigma associated with reporting, lack of awareness of the criminal nature of abuse, and political and social implications of reporting (Burczycka, 2017). Most of the available research of childhood abuse is based on retrospective recall in adult populations, which presents additional concerns regarding reliability and accuracy (Burczycka, 2017). Additionally, given the potentially long latency period since last trauma exposure, an individual may not

identify their childhood trauma in a way that satisfies *Criterion A* in the assessment of PTSD. In terms of epidemiological studies of PTSD, there is evidence that peak exposure to multiple trauma experiences occurs between the ages of 16 and 20 (Hidalgo & Davidson, 2000; Van Ameringen et al., 2008). Based on the best available data, the majority (61%) of Canadians who met PTSD criteria reported a history of childhood trauma making this an important priority for PTSD research efforts (Van Ameringen et al., 2008).

Findings from the 2014 Canadian General Social Survey indicated that one in three Canadians (12.4 million) endured some form of child maltreatment (e.g., direct or witnessing physical and/or sexual abuse) before the age of 15 (Burczycka, 2017). Physical abuse was the most commonly reported childhood trauma (26%) with males reporting this type of trauma exposure more than females (31% compared to 22%; Burczycka, 2017). In terms of sexual abuse, 8% reported experiencing sexual abuse during childhood with females being three times more likely to indicate this type of maltreatment than males (12% vs. 4%; Burczycka, 2017). Overall, 16% reported being subjected to *both* types of abuse in childhood, with females more than three times as likely to have experienced physical *and* sexual abuse (24%) compared to males (8%). Among the Canadians that reported childhood physical and/or sexual abuse, over 35% indicated they had experienced greater than seven repeated exposures to the abuse with 15% reporting being abused at least 22 times (Burczycka, 2017). Physical abuse was most likely to be caused by a parent/guardian (61%) whereas sexual abuse was most often perpetrated by someone outside the direct family (61%; Burczycka, 2017). An alarming 93% (11.5 million) of victims of childhood abuse indicated they did not report the abuse and 67% (8.3 million) of victims had never spoken about the abuse to anyone, including close friends or family (Burczycka, 2017). Of particular concern is the reduced likelihood that victims who have never

spoken about the abuse to anyone actually seek treatment given the stigma, embarrassment, and shame that often surrounds making such an admission. Although there remains an ongoing challenge to obtaining precise data given the challenges associated with the retrospective nature and stigma, it is likely that the existing prevalence rates of childhood abuse and PTSD are much higher. Research efforts that aim to address childhood trauma exposure remain a sensitive, challenging, and important public health priority.

Barriers and Facilitators of Seeking PTSD Treatment

Concerns surrounding access to PTSD treatment among young adults include significant barriers (e.g. wait-times, financial constraints, geographical limitations) that result in a fraction of those requiring treatment receiving such treatment (Bradley et al., 2005; Gulliver et al., 2010; Hudson, 2012). Approximately 18 to 24% of young adults with clinical mental health symptoms actually seek medical or clinical help, leaving a large proportion untreated (Gulliver et al., 2010). In a systematic review of 22 published studies of perceived barriers and facilitators of accessing mental health treatment, Gulliver et al. (2010) highlighted that, compared to middle-age to older-adults, young adults are less likely to seek traditional forms of PTSD treatment (e.g., individual, in-person therapy) due to associated costs, perceived stigma and embarrassment, confidentiality anxieties, trust concerns, and challenges with accurately self-identifying symptoms (Gulliver et al., 2010). Although limited research surrounding the uptake and adherence to clinical treatment among young adults exists, there is preliminary evidence that key facilitators that motivate young adults to seek active mental health treatment may include anonymous online access, social support by peers, positive help-seeking experiences, trust in the provider, and a preference for self-reliance and self-guidance to solve problems (Gulliver et al., 2010). Based on these findings, tailored treatment delivery for young adults experiencing PTSD symptoms could be remedied

with online, cost-effective, self-reliant, anonymous adjunctive treatments in combination with one-on-one psychotherapy approaches.

Integrated Treatment Approaches for PTSD

Given the preference of young adults to rely on themselves and seek self-help as a treatment for mental health challenges, traditional talk therapy alone may be insufficient for young adult trauma survivors (Gulliver et al., 2010; van der Kolk, 2006). Indeed, the most widely recommended treatment for PTSD is cognitive behavioural therapy (CBT) with a qualified therapist (Mendes et al., 2008). However, since PTSD presents significant challenges in emotional and physiological arousal regulation, additional self-management strategies that emphasize somatic-sensory body-based awareness practices in conjunction with CBT may add further benefits to existing PTSD treatment approaches.

Behavioural approaches, including exercise and yoga, have been increasingly relied on in PTSD symptom management, but have largely been explored as stand-alone modalities rather than as an integrated approach with psychotherapy (Rosenbaum et al., 2015; van der Kolk et al., 2014). Similarly, mindfulness-based meditation, a practice involving moment-to-moment focal attention and non-judgmental awareness of cognitions and somatic sensations, has also emerged as an effective stand-alone treatment modality for self-regulation and mental health challenges (Bishop et al., 2004; Kabat-Zinn, 2003a; Lutz et al., 2008). In addition to psychological health benefits, these self-managed behavioural approaches have been found to improve self-regulatory mechanisms of autonomic nervous system balance that often get disrupted after trauma (Bishop et al., 2004; Kabat-Zinn, 2003a; Lutz et al., 2008). Since PTSD is characterized by difficulties with emotion regulation, impulse regulation, and chronic symptoms of hyperarousal, the integration of online delivery of yoga and mindfulness self-management practices with

psychotherapeutic support may be a more useful way to alleviate symptoms of PTSD while meeting the tailored needs of the young adult population than stand-alone approaches. In Chapter 2, a review of the literature highlighting the potential benefits of yoga and mindfulness as adjunctive treatments with psychotherapy are highlighted. Within Chapter 2, an in-depth review of the physiological mechanism of the trauma response is also presented to build a compelling case for treatment approaches that consider the physiological processes involved in PTSD recovery *in conjunction* with the psychological impact of trauma.

Dissertation Aims

Given the challenges pertaining to the accurate assessment and quantification of trauma exposure and PTSD in the *DSM-5*, a primary aim of this dissertation was to include a broad range of trauma exposures and subsequent PTSD symptom presentations among young adults with PTSD who represent an understudied population experiencing distress and functional impairment. Another initial aim of this dissertation was to understand the effectiveness of online clinical treatment that included self-guided mindfulness and yoga among a *clinically-relevant* population. The candidate and her supervisor aimed to build on previous clinical intervention work by creating an integrated online treatment program, which introduced self-management components of mindfulness and yoga with existing CBT therapy (CBT-MY). Conducting an experimental trial to evaluate the effectiveness of an online CBT-MY program for PTSD and discussing the implications of the findings for future research was a priority for this dissertation.

Study Purpose

The purpose of this study was to develop and evaluate an 8-week online CBT-MY therapeutic intervention in an understudied sample of young adults with PTSD. The novelty of

this study includes an additional evaluation of objective psychophysiological outcomes of the 8-week intervention examining pupillometry and heart rate variability in a clinical sample of PTSD participants, and comparisons with cross-sectional data from a convenience sample of non-PTSD participants with no prior history of mental health conditions.

Overview of Research Design

This single-arm experimental trial was registered on ClinicalTrials.gov (identifier: NCT03684473). A single-arm experimental trial was the preferred method to gather the preliminary evidence of an online CBT-MY intervention in the reduction of PTSD symptom severity. In a single-arm trial, a sample of individuals with a common condition, in this case PTSD, receives an intervention and is prospectively followed to observe the response and outcomes (Evans, 2010). This design is considered the preferred trial design when the primary aim is to provide preliminary evidence of the intervention effectiveness and collect additional information about the safety, applicability, adherence, and level of interest (Evans, 2010). Often single-arm trials are used prior to launching a full randomized controlled trial as they provide initial evidence of intervention effects and identify areas of improvement for larger-scale replicability (Evans, 2010). Additionally, single-arm experimental trials are an appropriate method in which waitlist control arms are not desirable, particularly when treating severe mental health conditions (Evans, 2010). A single-arm experimental trial design does present limitations in comparison to a randomized controlled trial, namely with the interpretation of the findings given the inability to make comparisons with a control-group. As a remedy to enhance the rigor of the objective measures obtained in this clinical trial, PTSD data was compared with cross-sectional data of a convenience cohort sample of non-PTSD participants with no prior history of mental health diagnoses or trauma exposure. The non-PTSD convenience sample did not receive

the intervention and were recruited to complete a single time measure of the 25-minute psychophysiology measures to allow for comparisons with the PTSD sample. Despite limitations, the single-arm experimental trial with a non-PTSD comparison cohort will provide preliminary evidence for effect sizes for future randomized trials investigating long-term treatment and follow-up for PTSD.

Significance of the Study

At the time this clinical trial was conducted, no known study had been undertaken to evaluate the changes in PTSD symptoms after completion of an 8-week online CBT-MY intervention for adults, aged 18-35 years, with PTSD. This clinical trial used a combination of self-reported psychometric outcomes of PTSD, depression, and anxiety combined with objective pupillometry and HRV psychophysiology measures in a pre-post design to detect improvement in symptom severity and autonomic regulation. Thus, this clinical trial represents the first known clinical trial of its kind in Canada to examine a CBT-MY approach to healing PTSD using *both* psychometric and psychophysiological outcomes. The findings from this study have important implications for the clinical treatment of PTSD. Particularly, the findings from this clinical trial will lend support to the future development of online treatment delivery that directly addresses the known financial, geographic, and wait-time barriers of receiving in-person clinical treatment.

Operational Definitions

For the purposes of this dissertation, the following operational definitions were used:

Trauma-Sensitive Yoga

Trauma-sensitive yoga is an evidence-based, adjunctive treatment for repeated and multiple trauma exposures and PTSD. Developed at the Trauma Center in Brookline, Massachusetts,

trauma-sensitive yoga is a program offered for traumatized individuals at the Center for Trauma and Embodiment at the Justice Resource Institute in Boston, Massachusetts (Emerson & Hopper, 2011). Trauma-Sensitive yoga is based on central components of Hatha yoga, where participants move into a series of physical forms using the breath. Elements of Hatha yoga are modified using a trauma-informed lens to maximize experience of empowerment and to cultivate the safe restoration of mind and body (Emerson & Hopper, 2011). This form of yoga does not use physical hands-on adjustments, refrains from the use of traditional Sanskrit terminology, and emphasizes that the participant be in charge of themselves based on a felt sense of their own body (Emerson & Hopper, 2011; van der Kolk et al., 2014).

Young Adult

No standardized consensus on the age-range of young adulthood currently exists in the literature. Because this research study recruited young adults enrolled in post-secondary education, a young adult was defined as a person between the ages of 18-35. This age range was selected based on two factors. First, under section 125, Duty to Report, of the Child, Youth and Family Services Act (Government of Ontario, 2017), every person who has reasonable grounds to suspect that a child is in need of protection must immediately report the information to a Children's Aid Society. Youth, ages 16 and 17, are considered eligible for protection under this act. Therefore, in consultation with the Registered Clinical Psychologist overseeing this research study, it was ethically decided that the minimum age of eligibility for the clinical trial would be 18. Second, it was acknowledged that many extenuating circumstances (e.g., mental health challenges, financial constraints, parenthood) may impact a young adults' post-secondary education journey. With this in mind, we broadened our age range to age 35 to account for these circumstances.

Navigation of Dissertation

Chapter 2 immediately follows and presents a comprehensive literature review examining the psychophysiology of the trauma response, the proposed theoretical perspectives that guide the dissertation, an overview of the treatment approaches for PTSD, and two established biomarkers of autonomic function that reflect psychopathology of PTSD. The methodology for the experimental trial is presented in Chapter 3 and the psychometric and psychophysiology results are summarized in Chapter 4. Chapter 5 of the dissertation concludes with a discussion of the findings, the clinical and research implications of the research conducted and future directions.

Chapter 2: Review of Literature

There has been substantial research on psychological trauma and PTSD largely attributed to the examination of symptoms that have presented combat veteran soldiers returning from war (Herman, 2015). The study of trauma in other contexts, notably sexual violence against women and children, or repeated exposure to historical or racialized trauma, is less established. Nonetheless, examination of the impact of trauma and subsequent PTSD on psychological functioning (e.g., depressed mood, negative self-beliefs) has been the major focus of existing research efforts. From a psychophysiological perspective, trauma and PTSD have been linked to structures located in the brainstem that are reflexive, manifesting as significant disruptions to the autonomic nervous system (ANS; Thayer & Brosschot, 2005; Levine, 1976; van der Kolk, 2006).

In this chapter, after a presentation of the impact of childhood trauma during young adulthood, existing literature pertaining to the biological and psychophysiological mechanisms of the trauma response in the brain and body will be comprehensively reviewed and summarized. These will be followed by an overview of current PTSD treatment approaches, reviewing their findings, highlighting existing gaps, and identifying established markers of autonomic function among clinical populations that are relevant for treatment and detection of PTSD.

Young Adulthood and Adverse Childhood Experiences (ACEs)

Early childhood experiences play a crucial role in the development of foundational skills and behaviours that span into adulthood. When these experiences are traumatic, deficits in social, emotional, and cognitive development occur, affecting overall health and well-being (Anda et al., 2006). When traumatic life events experienced during childhood are left untreated, mental health disruptions, including depressive and PTSD-like symptoms can be re-experienced during

stressful or complex life transitions during young adulthood (Anda et al., 2006; Boscarino, 2006; Brown et al., 2009; Coughlin, 2011), thereby increasing the risks of negative psychological and physical health outcomes. Trauma-related symptoms experienced in childhood are associated with negative outcomes in adulthood including higher rates of morbidities such as substance misuse, risk of self-harm, and suicide ideation, resulting in a reduced quality of life (Anda et al., 2006; Boscarino, 2006; Brown et al., 2009; Coughlin, 2011; Holman et al., 2016).

The largest investigation regarding the impact of childhood trauma comes from the Adverse Childhood Experiences (ACEs) study conducted in the United States (Felitti et al., 1998). ACEs include all types of direct abuse and neglect experienced before the age of 18 years in addition to exposure to parental mental illness, substance use, divorce, incarceration, and the witnessing of domestic violence (Felitti et al., 1998). Based on this definition, nearly 60 percent of adolescents in the US have experienced at least one lifetime ACE (Felitti et al., 1998). Felitti et al. (1998) also found that the greater the number of traumatic exposures during childhood, the higher the health-harming behaviours in adulthood (e.g., smoking, substance misuse, suicide attempts) and subsequent disease risks. Specifically, individuals who reported experiencing more than four categories of childhood trauma exposure were significantly more likely to have attempted suicide (Adjusted OR = 12.2), used illicit drugs (Adj. OR = 10.3), reported alcoholism (Adj. OR = 7.4), or experienced depression (Adj. OR = 4.6) compared to those with no childhood trauma exposure (Felitti et al., 1998). Further research on ACEs suggest that unresolved childhood trauma is linked to an increased risk of coronary heart disease, hypertension, hyperlipidemia, obesity, and cardiovascular disease in adulthood (Coughlin, 2011; Felitti et al., 1998). Strong evidence of associations and dose-response relationships have been found between the number of childhood trauma exposures and multiple risk factors for all-cause mortality in adults, including cardiovascular disease, cancer, increased risk of suicide, diabetes,

and substance misuse leading to accidental death (Brown et al., 2009; Felitti et al., 1998; Holman et al., 2016).

The impact of ACEs on life transitions experienced during young adulthood (e.g., identity formation, risk behaviours) can highlight additional areas of focus and opportunities for targeted intervention. To our knowledge, only one study by Davis et al. (2018) has explored the impact of ACEs on the dimensions of young adulthood (e.g., identity formation) proposed by Arnett (2000) discussed previously in Chapter 1. According to Davis et al. (2018) a higher number of ACEs were associated with less identity exploration (r = -.18, p < .001) and less self-focus (r -.24, p < .001) and an increased negativity/instability (r = .25, p < .001) during early adulthood (Davis et al., 2018). In terms of traditional social roles during young adulthood, higher ACE scores were associated with lower educational attainment (r = -.11, p < .001), but the magnitude of effect remained small and was not a significant mediator between ACEs and dimensions of young adulthood; there were also no significant associations between ACEs and martial status or parenthood (Davis et al., 2018). Nonetheless, experiencing ACEs were associated with higher levels of negativity/instability during young adulthood, further placing individuals who experienced ACEs at increased risks for clinical depression and unresolved PTSD (Davis et al., 2018).

While these results provide preliminary evidence for an association between ACEs and negative developmental trajectories during young adulthood, the study was limited to cross-sectional analyses and self-reported data which make generalizations difficult. Continued research investigating the impact of ACEs on subsequent developmental trajectories and mental health during specific life transitions, including young adulthood (e.g., entering post-secondary education, parenthood) would help identify where intervention efforts are most needed.

The Neurobiological Mechanism of the Trauma Response

Contrary to the common understanding, the trauma response is not predominantly a psychological manifestation, and includes a prominent physiological dimension that is reflected in the neurobiological changes within the brain and body (Lehrner & Yehuda, 2014; Levine & Frederick, 1997; van der Kolk, 2015). The following section reviews the literature examining the physiological mechanisms of the trauma response in the brain and body to help identify additional healing pathways.

Human beings have developed a biological system designed to fluctuate and swiftly adapt to multiple perceived daily stressors, such as: slamming on the brakes to avoid a car accident, responding with a startle when a door shuts loudly, tending to a crying child, or participating in an interview or exam. All of these varying stressors produce a similar physiological response within the body that helps mobilize an individual to prepare, respond to, and overcome the stressor (Levine, 1976; Selye, 1956; van der Kolk, 2015). Typically, when a stressor has passed and is no longer provocative, the body automatically returns to a more balanced and regulated state. Human beings fluctuate through the stress response cycle numerous times daily through a coordinated response system of mobilization and then a return to homeostasis (Levine & Frederick, 1997; Selye, 1956). With trauma, however, the stress stimulus resulting from the traumatic event may be extremely intense or possibly prolonged across a long period of time, making it increasingly difficult and challenging to move through the typical stress response cycle. When an individual has experienced trauma, the body has been exposed to such an extreme stress stimulus that the body's natural ability to move through the stress response and return to homeostasis becomes hindered, leading to a host of extreme and dysregulated bodily sensations, and related emotions and cognitions (Levine, 1976; Payne et al., 2015).

The Primitive Reptilian Brain, Stress Response, & Trauma

The neurobiological mechanisms comprising the trauma response was first described in MacLean's pioneering work on the triune brain model (See Table 1; MacLean, 1985, 1990). MacLean's research of evolutionary changes to the size, structure, and function of the human brain (ontogeny), suggests that the evolution of the human brain is organized into a hierarchical model of three distinct regions: a) the primitive brain structures, b) the limbic brain structures, and the c) the prefrontal cortices of the neocortex that are unique to human beings (MacLean 1985, 1990).

Table 2

The Evolution of the Human Brain (MacLean, 1985)

Brain Region	Evolution	Areas of the Brain	Function	Other Names
Reptilian Brain	Oldest part of the brain	Brainstem, basal ganglia, autonomic nervous system	Survival instincts, autonomic function of organs, stress response	Primitive brain, survival brain
Paleomammalian Brain	Second region of the brain to evolve	Hippocampus, cingulate gyrus, amygdala, the parahippocampal gyrus, parts of the thalamus	Somatosensory and emotional processing, implicit memory	Limbic system, Emotional Brain
Homo Sapiens Brain	Newest, most evolved part of the human brain	Neocortex, prefrontal cortices	Intellectual and executive functions, rational decision making, conscious thought and self-awareness	Rational brain, thinking brain

Based on Maclean's classical model of the triune brain, the primitive reptilian brain is the phylogenetically oldest part of the brain shared among all vertebrates (MacLean, 1985, 1990). It is responsible for primal, protective survival instincts, and consists of the brainstem, cerebellum,

and basal ganglia within the central nervous system (CNS; MacLean, 1990). The reptilian brain, consisting of a network of neuronal, hormonal, and physiological systems that activate in response to threat or danger, controls the involuntary, autonomic function within the body's circulatory, respiratory, temperature regulation, digestive, and sensory (e.g., spatial balance) systems (MacLean, 1990). Since the reptilian brain is not involved in conscious thought, it primarily registers sensory stimuli (i.e., neuroception), a process whereby the autonomic nervous system (ANS) monitors and evaluates cues of safety, danger, or threat (e.g., gut feelings or intuitions that a situation is unsafe; MacLean, 1985, 1990).

The Autonomic Nervous System

The ANS, an involuntary part of the reptilian brain, coordinates autonomic physiological, metabolic and thermoregulatory responses in the body to meet internal (e.g., fever, illness, excretion of toxins) and external (e.g., injury, stress, trauma) demands (MacLean, 1985; Wehrwein et al., 2011). Structures of the brain, spinal cord, and the peripheral nervous system make up the ANS to regulate the involuntary physiological processes of nearly every organ in the body including heart rate, blood pressure, sexual arousal, sweating, digestion, and waste elimination (MacLean, 1990; Wehrwein et al., 2011). The ANS is, in turn, comprised of 3 distinct divisions: the sympathetic nervous system (SNS), parasympathetic nervous system (PNS) and the enteric nervous system (ENS). The SNS and PNS contain nerve fibers that innervate smooth muscle (e.g., blood vessels), cardiac muscle, exocrine (e.g., sweat glands) and endocrine (e.g., pineal) glands (Wehrwein et al., 2011). The ENS is a web-like structure of sensory, motor, and inter-neurons embedded in the lining of the digestive tract to control digestion (Costa et al., 2000). The SNS and PNS function antagonistically (e.g., heart, bladder), synergistically (e.g., iris ocular muscle) or independently (e.g., SNS – blood vessels, PNS –

nasopharyngeal gland) to help ensure organs and tissues in the body maintain physiological balance and equilibrium in the presence of chemical, physical, or emotional stress, threat or danger (Wehrwein et al., 2011). The ANS communicates with the central nervous system (CNS) via a reflex arc that includes: an afferent limb (e.g., baroreceptors) that transmits sensory impulses from the PNS to the CNS, and an efferent limb (e.g., preganglionic, postganglionic fibres) that carries nerve impulses from the CNS to the peripheral tissues or organs (Bankenhally & Krovvidi, 2016).

The Sympathetic Nervous System

The SNS is most commonly known as our "fight or flight" survival system, as it helps mobilize the body to respond to fear, threat, or danger. The preganglionic neurons of the SNS are located in the thoracic and lumbar regions (T1 to L2) of the spinal cord (McCorry, 2007; Wehrwein et al., 2011). The preganglionic neurons have synaptic connections with postganglionic neurons that target peripheral efferent organs or glands (Wehrwein et al., 2011). When the SNS is activated, an automatic coordinated sequence of hormonal, neuronal, and physiological responses occur within the body. In particular, in the presence of danger or threat, the nerve fibers from the SNS signal the release of epinephrine (e.g., adrenaline) and norepinephrine into the bloodstream, which act on adrenergic receptors (e.g., adrenal medulla) to rapidly elevate the heart rate and blood pressure to circulate nutrient-rich blood to the skeletal muscles and other vital organs. Additionally, respiration rate increases (e.g., bronchodilation) to increase oxygen delivery to the brain to enhance alertness, and greater amounts of glucose are released into the bloodstream to supply energy to *fight off* or *flee from* the danger (Bankenahally & Krovvidi, 2016; McCorry, 2007). In addition, pupils will dilate to allow for improved distance

vision, body temperature will rise (e.g., perspiration), and digestion ceases automatically as part of the fight or flight survival response (Bankenahally & Krovvidi, 2016).

As the initial adrenaline rush subsides from SNS activation, the hypothalamic-pituitary-adrenal (HPA) axis becomes activated if the stressor remains activated. The HPA is a second stress response system, consisting of the hypothalamus and the endocrine (e.g., pituitary and adrenal glands) systems (Smith & Vale, 2006). Briefly, neuronal signals in the hypothalamus synthesize the release of corticotropin-releasing factors (CRF). CRF then binds to receptors in the pituitary gland to signal the release of adrenocorticotropic hormone (ACTH). ACTH, travelling within the bloodstream to the adrenal glands, binds to receptors on the adrenal cortex to signal the release of cortisol, a steroid hormone, into the bloodstream to sustain the metabolic, cardiovascular, and behavioural responses required for a sustained response when danger or threat persists (Smith & Vale, 2006).

The Parasympathetic Nervous System

In contrast, when the stressor is no longer present, the PNS activates and responds as a "brake pedal" on the SNS to return the body from SNS activation (e.g., stress response, mobilization) to homeostasis, rest, and regulation (McCorry, 2007). The PNS is often termed the "rest and digest" system, given the role it plays in energy conservation, restoration, digestion, and regulation of the organs and tissues within the body (McCorry, 2007; Wehrwein et al., 2011). The neurons of the PNS are located in the brainstem nuclei (e.g., cranial nerves) and sacral region (e.g., pelvic cavity viscera) of the spinal cord (Bankenahally & Krovvidi, 2016; McCorry, 2007; Wehrwein et al., 2011). When the PNS is activated, the neurotransmitter acetylcholine (Ach) is released and acts on muscarinic receptors, to facilitate the return of blood pressure (e.g., vasodilation) and heart rate to normal levels, increase secretion of saliva and

digestion activity (e.g., releases bile, digestive enzymes, excretion), slows our breath rate, and leads to miosis of the pupils (e.g., constriction) to return to near vision (McCorry, 2007). , The vagus nerve (i.e. the 10th cranial nerve), one of the largest cranial nerves in the body, is located within the PNS. The vagus nerve makes up 75% of all PNS nerve fibers, and plays a critical role in the response to and recovery after trauma exposure (Porges, 2007).

The Polyvagal Theory & The Trauma Response in PTSD

The polyvagal theory (PVT) proposed by Porges (1995) provides an integrative perspective of how neural mechanisms support adaptive behaviours. Studies examining the neuroanatomy and neurophysiology of the mammalian ANS have identified an additional survival mechanism, (beyond SNS "fight or flight" and PNS "rest and digest") within the PNS which is mediated by the vagus nerve (Porges, 1995, 2007). As originally articulated by Dr. Stephen Porges (1995, 2009), the PVT identifies a neurophysiological framework for understanding three phylogenetically ordered stages of ANS development that have distinct autonomic sub-systems that regulate social and adaptive survival behaviours: 1) The Immobilization Response, known as the "Freeze" response, the most primitive mammalian response to danger and trauma exposure that leads to vaso-vagal syncope (e.g., fainting), death feigning, and behavioural shut-down (Porges, 1995, 2007), 2) The Mobilization Response, also referred to as SNS "Fight-Flight" activation, and 3) The Social Engagement System, an evolved system in mammals who raise and rear young, associated with ascertaining safety, connection and belonging through facial expression, vocalization and listening (Porges, 1995, 2007). According to PVT, the three ANS response strategies unfold in accord with an ordered hierarchical model. The PVT then proceeds to explain the neurophysiological distinctions and adaptive functions of the two distinct branches of the vagus nerve: the dorsal vagal complex and

the ventral vagal complex in symptomatic and healing responses to trauma (See Table 2; Porges, 1995, 2009).

Table 3

Phylogenetic Stages of the Polyvagal Theory (Porges, 2007)

Order	ANS Component	Behavioural Response	Lower Motor Neurons
I	Dorsal Vagal Complex (Unmyelinated vagus)	Immobilization, death feigning, vaso-vagal syncope/fainting, dissociation, behavioural shut-down passive avoidance defence system	Dorsal motor nucleus of the vagus nerve
II	Sympathetic-Adrenal Nervous System	Mobilization, "Fight of Flight," Aggressive or active defence system	Spinal cord
III	Ventral Vagal Complex (myelinated vagus)	Social engagement, safety, communication, self-soothing, calming, inhibit SNS	Nucleus ambiguus

The Dorsal Vagal Complex: The Immobilization Response

The dorsal vagal complex (DVC), located in the fourth ventricle of the caudal brainstem, originates in the dorsal motor nucleus of the vagus nerve (DMNV) and is considered the most primitive phylogenetic state of the ANS common to all vertebrates (Porges, 1995). The primary motor pathways from the DMNV include the unmyelinated vagus nerve structures that innervate the viscera below the diaphragm and provide neural control of subdiaphragmatic organs (e.g., stomach, liver, pancreas, small intestine; Porges, 1995). The DVC also provides inhibitory input to the sinoatrial node (SA) of the heart via unmyelinated fibers. According to the PVT, the DVC plays a role as a secondary defense strategy in response to extreme levels of threat or danger when sympathetic "fight or flight" neural activation is prolonged and may be unsuccessful in re-establishing safety (Porges, 1995, 2009). If escape from danger appears impossible, an automatic

survival response, mediated by the DVC of the PNS, activates to quickly move a person into a state of "freeze" or *immobilization* to conserve metabolic resources (Porges, 1995, 2009). The immobilization response occurs on a spectrum and may include the following: a) defecation or urination as a result of increased motility of digestive processes and rapid relaxation of sphincter muscles, b) bradycardia due to the influence of the DVC on the sinoatrial (SA) node, c) apnea (breath *cessation*) as a result of vaso-vagal syncope (i.e., fainting), and d) dissociation, including the inability to move parts of the body and difficulty accessing words (Porges, 2007). This unique physiological state is highly adaptive for mammals when faced with imminent death in order to avoid additional psychological and somatic harm, or in a last attempt to survive by appearing less viable to a perpetrator (Porges, 2007).

According to the PVT, long after a traumatic experience has ended, trauma survivors may chronically oscillate between the "fight or flight" or the "freeze" immobilization states, resulting in displays of polarized extremes of hypervigilance and hyperarousal along with dissociation, numbness, or the experience of feeling completely separate from the body (Porges, 2007, 2009; van der Kolk, 2015). These maladaptive oscillations are a likely result of not being able to successfully regulate SNS hyperarousal and the dorsal vagal immobilization states due to chronically re-experiencing of the trauma (e.g., intrusive memories, flashbacks) which can lead to avoidant coping behaviours (e.g., numbing, dissociation, behavioural shut-down; Porges, 2007, 2009). The immobilization response is evoked in unresolved trauma where the past intrudes into the present through unpredictable flashbacks, triggers, and re-living of the traumatic event, making it difficult to concentrate, focus, or feel a sense of energy, vibrancy or aliveness (van der Kolk, 2015). As a result, dorsal vagal immobilization (e.g., dissociation) becomes the primary defence strategy unique to trauma survivors to help protect against re-experiencing the traumatic exposure.

The Ventral Vagal Complex: The Social Engagement System

From an evolutionary perspective, the PVT has identified the ventral vagal complex (VVC) as the newest distinct subsystem that serves the *social engagement system* (SES; Porges, 1995, 2009). The SES is the primary autonomic state when an individual perceives their environment as safe and feel a strong sense of belonging, connection and safety within a social context (Porges, 1995, 2009). The SES via the VVC is regulated by the nucleus ambiguus, and is dependent on the myelinated arm of the vagus nerve that inhibits SNS dominance on the heart and the HPA axis (Porges, 2007). The myelinated vagus nerve fibers integrate with brainstem nuclei that regulate regions of the body above the diaphragm. The myelinated arm of the vagus nerve include somatomotor components that regulate striated muscles of the face, vocal cords, larynx, inner ear, eyes, and visceromotor components that regulate heart and lungs (Porges, 2007). The nerve structures that define the VVC also help regulate eye contact and gaze, differentiate the human voice (e.g., maternal voice) from background noise, identify voice intonation, and regulate emotional display through facial expression and gestures to promote social behaviour and communication required for safety (Porges, 2007). The somatomotor neural pathways involved in social behaviour are shared and integrated (e.g., raised eyelids activates middle ear) to promote both engagement with the social environment and detection of safety in the social environment.

The SES also includes the visceral efferent neural pathways of the myelinated vagus nerve that innervate visceromotor components of the heart and lungs. These neuronal circuits exert an inhibitory influence on the heart to reduce SNS dominance (e.g., “fight or flight”) mediated by the myelinated vagal efferent fibers on the sinoatrial node (SA) and bronchi resulting in a lowered heart rate, reduced blood pressure, and regulated respiration rate, all changes that can promote social engagement and safety. When the SES is operating, the ANS

supports growth, restoration, and equilibrium. If the SES does not detect safety, more primitive neuronal systems are co-activated (e.g., SNS "fight or flight" or DVC immobilization) and recruited sequentially.

Based on PVT, dysregulations in somatomotor and visceromotor components of the VVC is common psychiatric disorders like PTSD (Porges, 2007). A dysregulated SES, often referred to as low vagal tone, affects both behavioural and autonomic outcomes. A wide range of defensive behaviours (e.g., hypervigilance, withdrawal, flat affect) and reduced vagal influence of the myelinated vagus on the SA node subsequently lead to SNS or DVC dominance as a baseline autonomic state. Among individuals with PTSD, PVT suggests that long-term disruption of the SES results in reduced vagal tone and autonomic dysfunction indexed by a reduced respiratory sinus arrhythmia (RSA) and subsequent decreased heart-rate variability (HRV; Porges, 2009; van der Kolk, 2006) even in states not considered experientially traumatic (van der Kolk, 2006).

Criticisms of the Polyvagal Theory

The PVT has provided a neuroscientific perspective for understanding the link between social behaviour and autonomic function for over 20 years. Indeed, the PVT has been increasingly applied to explain a wide range of disorders, including autism, anxiety disorders, and PTSD psychopathology (Porges 2003, 2011). Despite convincing evidence by Porges, the main criticisms of the PVT are the lack of direct empirical evidence testing this theory and questions surrounding the evolutionary underpinnings of the vagal control of HRV (Grossman & Taylor, 2007). Other criticisms of PVT have suggested that the evolution-based speculations made by Porges in relation to RSA, vagal tone and behavioural phenomena in mammals are inaccurate depictions of vagal control of the heart that can lead to misinterpretation of

cardiovascular autonomic mechanisms (Berntson et al., 2007; Grossman & Taylor, 2007). For example, there is a body of research suggesting that: a) respiration can confound the relationship between RSA and cardiac vagal tone, b) between-subject associations between RSA and vagal tone are weak, c) RSA amplitude may not be purely a vagal measure given it is also jointly affected by sympathetic beta-adrenergic tone, and d) RSA and cardiac vagal tone may dissociate under certain circumstances (e.g., pharmacological enhancement of cardiac baroreflex), and shows a quadratic relationship with vagal tone (Berntson et al., 2007; Grossman & Taylor, 2007). While evolutionary cardiovascular physiology is beyond the scope of this dissertation, it is important to note that differences in interpretation of RSA as an index of cardiac vagal tone remain within the field and warrant further examination.

The Neurovisceral Integration Model and Autonomic Function

Built on the foundation of PVT, the neurovisceral integration model (NIM) is an expanded framework that explains the link between psychopathology, vagal tone, autonomic flexibility/inflexibility, and adaptability to stress (Thayer & Lane, 2000). In terms of PTSD, primary emotional and behavioural states include fear, panic, avoidance and hypervigilance (Friedman, 2007). Thus, according to NIM, a diagnosis of PTSD can be logically associated with a specific psychophysiological pattern indexed by a predictable ANS response pattern (Friedman, 2007). Within the CNS circuitry exist cortical and subcortical neural pathways that influence the physiological response to emotional and environmental stress (Thayer & Lane, 2000). Based on the NIM, a regulated response to emotional and environmental stimuli is a function of the integrated circuitry of the CNS that involves behavioural, cognitive, and affective inhibition (Thayer & Lane, 2000). Accordingly, in psychiatric conditions that are rooted in fear, the NIM predicts reduced vagal tone by changes in the neural networks involved in autonomic,

emotional, and cognitive self-regulation. Self-regulation is the ability to regulate behavioural impulses, thoughts, and emotions to meet psychological and physiological demands (Thayer & Lane, 2000). The NIM indicates that SNS and DVC activation, CNS control, and neurotransmitter processes all play critical roles in the neurophysiological symptoms of PTSD (e.g., hypervigilance). These ANS regulatory patterns and emotion regulation processes can be indexed by an empirically validated measure of cardiac vagal tone known as heart-rate-variability (HRV; Thayer & Lane, 2000).

The subsystem of brain regions involved in autonomic self-regulation and adaptivity is collectively known as the Central Autonomic Network (CAN; Thayer & Lane, 2000). The CAN coordinates autonomic, endocrine, and behavioural responses to environmental demands. The primary brain regions of the CAN include the anterior cingulate, insula, prefrontal cortices (PFC), amygdala, and the hypothalamus (Thayer et al., 2009; Thayer & Lane, 2000). These structures are involved in bidirectional communication and are reciprocally connected. In addition, the PFC sends inhibitory neural circuits within the CAN and are associated with self-regulatory function (Thayer & Lane, 2000). In environments perceived as safe, the PFC exerts inhibitory control of the subcortical brain regions, including the amygdala, a brain region involved in threat detection and emotional responses (Thayer & Lane, 2000). During trauma exposure, the primary emotion experienced is fear (Thayer & Lane, 2000). In the context of trauma exposure, PFC inhibitory control is disrupted and diminishes, leading to hyperactivity in subcortical regions, including an exaggerated activation of the amygdala linked to hypervigilance, SNS hyperarousal, and perseverative cognition (Thayer et al., 2009).

According to the NIM, a healthy physiology is expressed in high levels of flexibility and adaptive variability in HRV. This has important relevance to the pathology of PTSD, which is marked by rigidity and low variability in ANS influence (e.g., consistently elevated HR and

blood pressure during resting states). The ANS output of the CAN is mediated through pre-ganglionic SNS and PNS neurons that innervate the SA node of the heart via stellate ganglia and the vagus nerve (Fieldman, 2007). Cardiac vagal efferent nerve fibers, that dominate cardiac control, in turn send impulses to the CAN, suggesting that the inputs and outputs of the CAN are directly linked to HRV (Fieldman, 2007). The self-regulatory influence of the PFC inhibitory circuits is further linked to cardiac function via the vagus nerve, via an inhibitory influence on the heart (Fieldman, 2007). Neuroimaging studies have predicted cardiac vagal tone, indexed by vagally-mediated HRV, by observations of the PFC function (Friedman, 2007). Evidence shows that higher resting high frequency (HF) HRV is associated with optimal PFC function that support autonomic flexibility and behavioural adaptability to a range of stressors. In contrast, a low HF HRV is associated with diminished PFC regulation and results in heightened activation of the amygdala, which is linked with poorly regulated and maladaptive cognitive and emotional responses (Friedman, 2007).

Low vagal control, indexed by a low HF HRV, suggests a failure of positive feedback mechanisms that support flexible autonomic function, and is a defining characteristic of PTSD (Cohen et al., 1997, 1998, 1999; Friedman, 2007). An elevated LF HRV and diminished HF HRV in PTSD has been a consistent finding compared to control participants (Cohen et al., 1997, 1998, 1999). Individuals diagnosed with PTSD have also demonstrated a ceiling effect in response to stress or traumatic stimuli as a result of chronic ANS hyperactivation, evidenced by non-significant HRV changes in response to conditions of stress (Cohen et al., 1998). Further research has demonstrated links between HRV measures of vagal tone and behavioural aspects of self-regulation (Friedman, 2007). Specific to PTSD, low vagal tone is associated with a wide range of maladaptive behaviours including reduced capacity to regulate emotions, increased vulnerability to stress, anxious states, and antisocial behaviour reflecting impaired central

nervous system (CNS) regulation (Cohen et al., 1999; Friedman, 2007). Low vagal tone is often reflected in maladaptive defense patterns such as chronic worry, perseveration, and hypervigilance, reflected as autonomic rigidity and vagal withdrawal evidenced by reduced HF HRV (Friedman, 2007). Thus, a wide range of stressful states evoke cardiac vagal withdrawal (e.g., low HF HRV) and serve as an important psychophysiological marker of PTSD.

Heart Rate Variability as a Biomarker of Autonomic Function

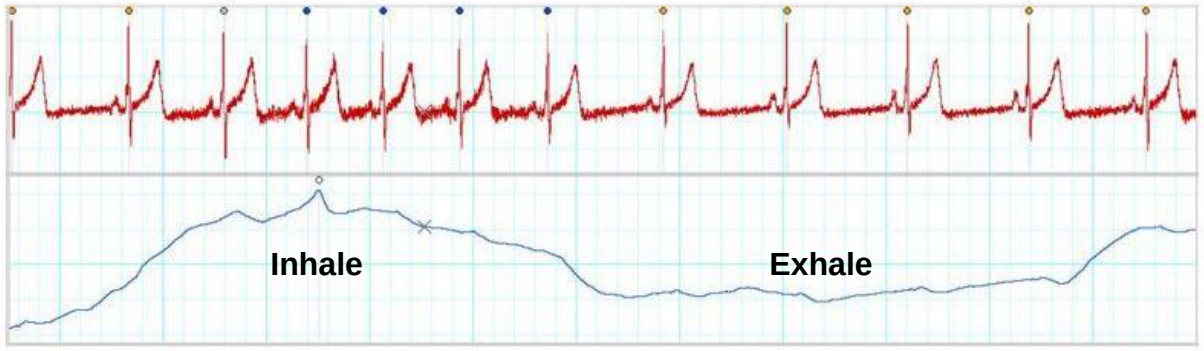
Heart rate variability (HRV) is an established biomarker of autonomic function and reflects variations in time between consecutive heartbeats (R-R intervals) in response to psychological and physiological stimuli (Acharya et al., 2006; Beauchaine & Thayer, 2015). The heart's pacemaker, known as the sinoatrial (SA) node, receives neural innervation by both pre-ganglionic SNS (i.e., stellate ganglia) and PNS (i.e., vagus nerve) neurons (Porges et al., 1994). HRV has become a useful measure of the interplay between the SNS and PNS influences on the heart and can be interpreted as an indicator of autonomic regulation and balance. Heart rate regulation is predominantly under the influence of the vagus nerve on the SA node where the myelinated vagus nerve fibers act as a "vagal brake" and rapidly change visceromotor control of the heart (Porges, 2011; Thayer et al., 2012). The "vagal brake" rapidly *inhibits* the SNS influence on the heart (e.g., lowers HR) and reduces HPA axis activity (e.g., lower stress response). Alternatively, when the "vagal brake" is released, it *disinhibits* PNS influence on the heart, leading to greater SNS dominance (e.g., accelerated HR; Porges, 2011; Thayer et al., 2012). In the context of traumatic exposure, given lower vagal PNS influences on the heart, the SNS influence is less counterbalanced by the PNS, resulting in rapid acceleration of HR (e.g., above 80bpm; Porges, 1995, 2007, 2011; Porges et al., 1994). In the context of trauma, this

blunted PNS influence produces chronic elevations in heart rate and lower variability in heart's beat-to-beat fluctuations.

The interplay of the SNS and PNS on heart rate is influenced by the depth and frequency of breath pattern, known as respiratory sinus arrhythmia (RSA). RSA is an accepted index of cardiac parasympathetic vagal tone and self-regulatory capacity (Porges, Doussard-Roosevelt & Maiti, 1994). RSA refers to the natural variation in heart rate (HR) pattern that co-varies with respiration frequency cycles (Porges, Doussard-Roosevelt & Maiti, 1994). RSA is not constant and varies as a function of respiration. This involves increased HR and shortened R-R beat intervals during inhalation, and decreased HR and lengthened R-R beat intervals during exhalation, as seen in Figure 1 (Allen et al., 2007; Kirk Chang et al., *in press*).

Figure 1

Example of Normative Respiratory Sinus Arrythmia (RSA)



Note. Image is from actual ECG data from this clinical trial (Kirk Chang et al., *in press*)

Thus, inhalation is under SNS influence (accelerating HR), and exhalation is under PNS influence (decreasing HR). The amplitude of RSA has been shown to provide an assessment of the state of the parasympathetic vagal tone and a vagal-mediated change in HR linked to respiration (Porges, 2007). This supports the notion that high RSA amplitude (increased HRV) is a positive index of social and emotional regulation during stress (Porges, 2007). Alternatively,

low RSA amplitude is an index of decreased HRV and suggests maladaptive social and emotional regulation linked to certain psychiatric conditions (e.g., anxiety disorders; Porges, 2007). The contributions of the SNS-PNS in modulating the HR R-R intervals of the QRS complex can be captured on an electrocardiogram (ECG) with specific frequencies. RSA, indexed as HRV, can be observed on an ECG and parasympathetic activity is measured using spectral analysis by capturing the high frequency (HF) HRV power spectrum. Two important frequency-domain parameters in HRV spectral analysis include the low frequency (LF) power (0.04-0.15Hz) and HF HRV (0.15-0.40Hz; Acharya et al., 2006). LF HRV captures both SNS and PNS influence on the heart and reflects baroreceptor-mediated blood pressure, whereas HF HRV reflects PNS vagal tone (Acharya et al., 2006; Task Force of the European Society of Cardiology [TFESC], 1996). Very low frequency (VLF) HRV is a less well established index and considered to reflect SNS activity and its influences, namely temperature, hormones, and metabolic processes (Friedman, 2007). Typically, RSA has a frequency of 0.25Hz and is indexed by HF HRV to indicate cardiac flexibility and autonomic regulation. International guidelines for the quantification of HRV suggest that high frequency bands of HRV (HF HRV: 0.15-0.4 Hz) reflect the 'brain-heart' bidirectional communication, whereas the low-frequency band (LF HRV: 0.04-0.15Hz) reflects sympathetic modulations of the HR (Acharya et al., 2006; TFESC, 1996).

Pupillometry as a Biomarker of Autonomic Function

Given the known heterogeneity among psychiatric disorders, additional psychophysiological markers of autonomic function may be helpful in further refining the neurophysiological correlates of psychopathology. Early foundational research examining the relationship between pupil response and mental activity highlighted pupil diameter as an index of

mental and autonomic activity that is sensitive to the amount of momentary cognitive load, level of task difficulty during short and long-term memory recall, and an individual's perceived ability to complete the task correctly (Hess & Polt, 1964; Kahneman et al., 1966, 1967, 1969). In one of the first trials to compare pupil response to other measures of autonomic activity (heart rate and skin conductance) during digit transformation tasks at three varying levels of difficulty, the pupil demonstrated the earliest, most consistent, and unique response pattern (Kahneman et al., 1969). A significant linear relationship with level of difficulty of mental task was found for pupil response ($p < .001$) compared to skin conductance (longer latency) and heart rate (non-significant findings; Kahneman et al., 1969).

The study of pupil response in clinical settings was originally used in the neurological diagnoses of Addison's disease and Horner syndrome (Graur & Siegle, 2013). As a quick, painless, and non-invasive means of detecting optic nerve dysfunction, drug effects, and autonomic function, the pupil response is a potentially useful and objective measure in the study of other disorders. Changes in pupillary movements are controlled by the muscles of the iris, which is innervated by both sympathetic and parasympathetic nerve fibers of the ANS (Snowden et al., 2016; Graur & Siegle, 2013). Pupillary dilation, reflecting SNS activation, occurs from the direct innervation of the dilator muscle of the iris (i.e., the dilator muscle expands the pupil to ~ 8 mm). Pupillary constriction, reflecting PNS activation, is due to the iris sphincter muscle which utilizes short ciliary PNS nerve fibers that cause constriction (miosis) and pupil contraction (Graur & Siegle, 2013). Research has linked changes in pupil dilation to brain functions in regions associated with emotional regulation, including the dorsolateral prefrontal cortex, anterior cingulate cortex, limbic system, locus coeruleus, and the noradrenergic system (Graur & Siegle, 2013). Stimulation of the SNS branch and/or inhibition of the PNS branch induces pupil dilation, whereas PNS activation (and SNS inhibition) causes the pupil to constrict (Graur &

Siegle, 2013; Kinner et al., 2017). Since increased pupil dilation occurs through mechanisms involving pathways to the medulla via amygdala stimulation (Graur & Siegle, 2013; Kinner et al., 2017) this is a promising peripheral index for a range of brain mechanisms affected by emotionally-salient information.

In psychological research, pupillometry to evaluate pupil dilation and eye tracking to evaluate gaze attention have both been recently identified as promising neurobiological markers of emotional processing, stress and mental health disorders. In a recent meta-analytic review, Armstrong and Olatunji (2012) examined results from eye tracking technology in characterizing affective disorders, and identified specific pupil response patterns for depression and anxiety. Among participants with anxiety, but not depression, attentional biases towards threatening stimuli were observed. Subjects with more severe anxieties demonstrated *lengthier* attentional foci on threatening stimuli versus those with lower anxiety levels (Armstrong & Olatunji, 2012). The increased attention to threatening stimuli may be relatively unique to anxiety disorders as a result of greater hypervigilance and a predisposition to detecting and interpreting threat (Armstrong & Olatunji, 2012; Kimble et al., 2014). Among those with depressive disorders, attentional *dwell time* on dysphoric, sad stimuli was significantly longer versus controls (Armstrong & Olatunji, 2012). The authors propose that depressed individuals dwell longer on sad images due to rumination tendencies and show reduced attention directed at events reflecting positive affect (Armstrong & Olatunji, 2012). Participants with depression were unable to disengage from dysphoric stimuli as quickly as controls, likely because of increased negative affect and negative cognitive biases. Results from this can be influential and extended to other psychiatric disorders, including PTSD, as this condition is often combined with comorbid conditions of anxiety and depression (Campbell et al., 2007). These findings yield support for the

use of pupillometry and eye-tracking technology in detecting patterns based on anxious and depressive symptomatology.

Recent research on the pupil response to emotional stimuli suggests that pupils become dilated in response to stimuli that require greater cognitive load and/or emotional intensity (Graur & Siegle, 2013; Kinner et al., 2017). Pupil dilation is innervated by specific brain regions involved in cognitive and emotional processing, particularly the dorsolateral prefrontal cortex, amygdala, and anterior cingulate cortex (Murphy et al., 2014; Siegle et al., 2003). As individuals process positive and negative emotional stimuli, the pupil size changes, responding systematically, depending on the type/severity of pre-existing stress or mental health disorders (Armstrong & Olatunji, 2012; Kinner et al., 2017). Specifically, pupils dilate when processing negative information and negatively provocative information more than neutral or positive stimuli (Graur & Seigle, 2013; Kinner et al., 2017). Pupil responses also demonstrate patterns implicated in attention control and cognitive appraisal (e.g., interpretations of emotion-provoking scenarios; Kinner et al., 2017). Thus, pupillometry is a quick, non-invasive assessment tool with a distinct potential for productive investigations of mental health disorders.

A growing body of research has examined pupillometry assessment in the estimation of mental health risks among adults with major depressive disorder (MDD) and their offspring (Burkhouse et al., 2014, 2015; Feurer et al., 2017; Kudinova et al., 2016), and adults exposed to a traumatic natural disaster (i.e., flooding; Woody et al., 2017). In support of a diathesis-stress model (i.e., predispositional vulnerability to stress as a result of life experiences), decreased peak pupil dilation, during the viewing of images of varying emotional expressions, predicted a significant increase in post-flood depressive symptoms in the women who were experiencing higher flood-related stress levels (Woody et al., 2017). Specifically, the odds of major depression disorder recurrence were five times higher among participants with low peak pupil dilation,

compared to those who exhibited moderate or increased peak pupil dilation (Kudinova et al., 2016). Similarly, significantly reactive pupil dilations to angry faces (but not sad or happy faces) among youth with depressed mothers predicted subsequent increases in their dependent interpersonal stress (Burkhouse et al., 2015; Feurer et al., 2017), and significant pupil dilation related to the viewing of angry and sad faces in women with histories of major depressive disorder (MDD) predicted MDD recurrence (Burkhouse et al., 2014; Kudinova et al., 2016). Lastly, children of mothers with a history of MDD were assessed for dilation responses to angry, happy, and sad faces. Follow-up assessments indicated children who exhibited greater pupil dilation to sad faces experienced elevated trajectories of depressive symptoms and a shorter time to depression onset (Burkhouse et al., 2015; Feurer et al., 2017). Findings from this research indicates that pupillary assessment can potentially provide a low cost, low impact method of predicting which at-risk individuals are more likely to experience future psychopathology and may help differentiate which individuals require longer term, follow up treatment.

Pupil dilation response, as a neural mechanism reflecting PTSD-based cognitive-emotional deficiencies, has been increasingly supported in recent empirical research. Cascardi et al (2015) examined group differences in pupil dilation based on eye-tracking during the presentation of threatening and neutral screen images. Those diagnosed with PTSD demonstrated greater pupil dilation in response to threatening versus neutral images and more sustained dilation states when compared to non-PTSD controls (Cascardi et al., 2015). Similarly, Kimble et al., (2010) examined visual attention to threatening and neutral stimuli among military veterans using eye-tracking technology. The authors found that those with higher levels of self-reported PTSD symptoms were more likely to look at threatening images first, hold the gaze on threatening images longer and had larger pupil dilation for threatening images compared to control groups (Kimble et al., 2010). Furthermore, Felmingham et al. (2011) employed eye-

tracking technology to investigate pupil reactivity to threatening stimuli in PTSD with similar results. Those in the PTSD group demonstrated more initial fixations to traumatic words and larger pupil dilation (Felmingham et al., 2011). Altogether, it appears that those diagnosed with PTSD are more likely to demonstrate larger reactive pupil dilations and longer fixations on threatening stimuli versus controls without PTSD, suggesting different pupillary patterns that are measurable. Pupillary reactivity to threatening stimuli may manifest as a stable marker in young adults currently experiencing PTSD symptoms and a marker of high-risk for those without a current PTSD diagnosis, perhaps paving the way for preventive treatment. Pupillary reactivity may also become a useful marker of therapeutic progress in the course of overcoming PTSD symptomatology.

The Neurobiological Impacts of Trauma in PTSD

Understanding the neurobiological impact of trauma has important implications for future targeted clinical research. An expanding body of research suggests that exposure to trauma can lead to detrimental deficits in cognitive-emotional processing and social functioning (World Health Organization, 2019), and increased risk of chronic disease (e.g., cardiovascular disease; De Hert et al., 2009; Sokal et al., 2004), particularly if trauma exposure is repeated or experienced during childhood (Anda et al., 2006; Brown et al., 2009; Dube et al., 2001; Felitti et al., 1998; Holman et al., 2016). Indeed, for many trauma survivors, the symptoms of PTSD can be long-lasting and linked to complex comorbid mental and physical health conditions, including anxiety and depression, substance misuse, personality disorders, and physical health problems (Bremner, 2006). Prolonged hyperactivity of the SNS has been linked to other comorbidities notably obesity, type II diabetes mellitus, and cardiometabolic disorders, as well as all-cause mortality (Anda et al., 2006; Brown et al., 2009; Holman et al., 2016; Kyrou & Tsigos, 2009).

At present, there are established neurobiological markers of trauma exposure linked to negative health outcomes including specific changes in brain structure and function that alter memory, influence autonomic regulation, and lead to neurophysiological changes in the hippocampus, amygdala, and medial prefrontal cortex (Bremner, 2006; Sherin & Nemeroff, 2011). According to Sherin & Nemeroff (2011), the neuroendocrine pathologies related to PTSD involves chronic dysregulation of the brain circuitry and the endocrine system that leads to hyperarousal, altered learning, and intermittent dissociative behavior. Key endocrine functions impacted by PTSD include the dysregulation of cortisol (i.e. blunted cortisol levels) and thyroid hormones as a result of constant activation and subsequent long-term dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis (Sherin & Nemeroff, 2011). The HPA axis is a major focus of PTSD given the role it plays in regulating the stress response system. Repetitive and extreme exposure to trauma leads to chronic activation of the HPA axis and generally leads to decreased cortisol concentration in individuals with PTSD when compared to Non-PTSD participants, although differences in the severity and timing of PTSD, symptoms, and comorbidities must be considered (Sherin & Nemeroff, 2011; Yehuda, 2006).

With the expansion of neuroimaging techniques in the last decade such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET), key brain structures and their activity are now linked to the pathophysiology of PTSD. These include the inhibition of the hippocampus and PFC, and increased amygdala reactivity to real or imaged threat (Bremner, 2006; Sherin & Nemeroff, 2011; Shin et al., 2006). Indeed, one of the major impacts of PTSD is the inhibition and reduced volume of the hippocampus brain region (Bremner, 2006; Sherin & Nemeroff, 2011; Shin et al., 2006). The hippocampus is responsible for memory processes, verbal descriptions of trauma, and fear conditioning (Bremner, 2006; Koenigs & Grafman, 2009; Sherin & Nemeroff, 2011; Shin et al., 2006), and helps individuals

distinguish between past and present memories (Koenigs & Grafman, 2009). When the hippocampus is impaired from prolonged exposure to traumatic symptoms, individuals may be at risk of re-experiencing the traumatic memories and associated symptoms even if it happened a relatively long time ago (Koenigs & Grafman, 2009). Furthermore, the decreased hippocampal volume resulting from PTSD is associated with diminished verbal memory and heightened trauma exposure, dissociative symptoms, depression and PTSD symptom severity (Shin et al., 2006). Therefore, trauma survivors with PTSD also struggle to describe their experiences, which has an important implication for identifying the most appropriate treatment approach (e.g., talk therapy vs. somatic sensory therapy). Similarly, trauma exposure has been demonstrated to be linked to inhibition and reduced volume of the PFC (Koenigs & Grafman, 2009; Sherin & Nemeroff, 2011; Shin et al., 2006), although the few studies undertaken limit generalizations. However, when the PFC is impacted by extreme trauma, emotional dysregulation may result including heightened fear, chronic anxiety and extreme stress response even to events seemingly unrelated to the original trauma (Bremner, 2006; Koenigs & Grafman, 2009; Sherin & Nemeroff, 2011; Shin et al., 2006).

Neuroimaging has also highlighted increased amygdala reactivity in individuals with PTSD. The amygdala, an area of the brain responsible for emotional processing, shows heightened activation in participants with PTSD in response to emotional stimuli (e.g., pictures, narratives) that are either perceived to be connected or not connected to their trauma exposure (Koenigs & Grafman, 2009; Shin et al., 2006). This heightened activity results in emotional dysregulation in the form of hypervigilance (e.g., excess anxiety, panic, or fear) and hyperarousal (e.g., SNS overactivation; Koenigs & Grafman, 2009; Shin et al., 2006). Reminders of the trauma, even long after the event occurred, activate brain regions in ways that disrupt the regulation of physiological arousal and the capacity to verbalize experience which, in turn,

interferes with present moment awareness (van der Kolk, 2006). Taken together, the hippocampus, PFC, and amygdala play vital roles in the regulation and mediation of traumatic stress. When these brain regions are implicated and rendered less functional as a result of PTSD, deficits in psychological and physical functioning occur and may increase the likelihood of comorbid conditions including other mood and behaviour disorders (e.g., anxiety, depression; Campbell et al., 2007) and physical ailments (e.g., hypertension, cardiovascular disease; Hendrickson et al., 2013). Therefore, in people diagnosed with PTSD, the ability to detect, respond, and recover from a traumatic stressor becomes blunted and results in SNS dominance (e.g., hypervigilance, increased heart rate; van der Kolk, 2006) with intermittent states of DVC immobilization (e.g., dissociation; van der Kolk, 2006). As a result of ANS dysregulation, individuals with PTSD are likely to feel constant fear and threat, even when significant amounts of time have passed since the original traumatic event.

Therapeutic Approaches for Clinical PTSD

Current therapeutic interventions for treating a wide-array of PTSD symptoms have typically focused on Cognitive Behavioural Therapy (CBT) frameworks in combination with pharmacological therapy, and more recently, eye-movement desensitization and reprocessing (EMDR; Bradley et al., 2005; Cuijpers, Berking, et al., 2013; Foa et al., 2010; Cuijpers, Sijbrandij, et al., 2013; Shapiro & Solomon, 2010; Ursano et al., 2004; US Department of Veteran Affairs, 2020). Among CBT frameworks, notably trauma-focused CBT, an individual learns to a) develop skills for emotional regulation (e.g., stress and anxiety management), b) identify distorted cognitions and interpretations of the traumatic event, and c) address chronic worry, intrusive memories, rumination, exaggerated self-blame, or negative self-concept linked to the trauma (Bradley et al., 2005; Foa et al., 2010; Foa & Rothbaum, 2001; Rothbaum et al.,

2000). In addition, many clinicians and treatments recognize the benefits of pharmacologic treatment for PTSD symptom management as an adjunct to psychological treatment, and not solely as a first-line treatment approach (Cusack et al., 2016; Foa et al., 2010). As a newer approach, EMDR is a technique administered by a qualified clinician whereby the individual is asked to hold a distressing image in mind while identifying associated bodily sensations and distorted cognitions, while engaging in bi-lateral eye movements following the finger or wand of a trained therapist (Shapiro & Solomon, 2010).

In-Person Cognitive Behavioural Therapy for PTSD

CBT is the most widely employed treatment for PTSD and is the most validated treatment framework (Foa et al., 2010; Rothbaum et al., 2000; Watts et al., 2013). Over the last two decades, several systematic reviews have examined CBT treatment efficacy compared to other psychological therapies. For example, one of the earliest systematic reviews conducted by Mendes et al. (2008) on 23 trials published between 1980 and 2005 (PTSD treatment group n = 898, Control n = 1025) examined remission rates, clinical improvement, and drop-out rates across different PTSD treatment approaches. Studies comparing CBT with EMDR found that PTSD remission rate was significantly higher in the CBT group (78.26%) than the EMDR group (35.48%, RR = 0.35; 95%CI: 0.16, 0.79; p = 0.01). However, meta-analysis of clinical improvements (e.g., symptom reduction) was not possible due to limited studies and the significant heterogeneity between studies made interpretation difficult (Mendes et al., 2008). While CBT showed to be more effective for study completers, evidenced by higher remission rates, than other therapies, no statistical differences were found in the intention to treat analysis in clinical improvement or compliance (p > .05). A small number of trials included in meta-analyses (Exposure Therapy n = 5; Cognitive Therapies n = 3) limits the generalizability of

findings. Significant methodological variability and heterogeneity across trials prevented the comparison of CBT with wait-list controls (Mendes et al., 2008).

In a more recent review of 64 trials published from 1980 to 2012, Cusack et al. (2016) examined a broader range of psychological treatments of PTSD including prolonged exposure (PE), cognitive processing therapy (CPT), and CBT-mixed therapies. Notably, when compared to inactive controls, CBT combined with exposure therapy (e.g., trauma-focused CBT) emerged as having the highest strength of effectiveness evidence (e.g., low risk of bias, consistency, precision of evidence) in treating PTSD (k = 7, N = 387, *SMD* = -1.27, 95% CI [-1.54 to -1.00], p < .05) and depression (k = 6, N = 363, *WMD* = -8.2, 95% CI [-10.3 to -6.1], p < .05) symptoms (Cusack et al., 2016). Additionally, CBT-mixed therapies (e.g., CBT interventions that added components such as psychoeducation, self-monitoring, stress management, relaxation/imagery training, mindfulness training) emerged has having moderate strength of evidence (k = 14, N = 825, *SMD* = -1.09, 95% CI [-1.4 to -0.78], p < .05) in treatment effectiveness supporting the use of multi-modal therapeutic approaches in treating PTSD (Cusack et al., 2016). Nevertheless, despite general evidence of effectiveness, the methodological limitations of the review (e.g., incoherent inclusion criteria) and high risk of bias of studies reviewed resulted in nearly 50% (n = 30) of the studies to be excluded from meta-analytic synthesis and findings need to be interpreted with caution.

Other systematic reviews that compared treatment effectiveness between EMDR and CBT have yielded inconsistent findings in treating PTSD. Early analyses have confirmed no differences (Davidson & Parker, 2001; Bradley et al., 2005; Seidler & Wagner, 2006), while others suggest trauma-focused CBT or EMDR to be superior to other therapies (Bisson et al., 2013; Ho & Lee, 2012; Capezzani et al., 2013). In a recent systematic review of 11 trials (N = 424) by Chen et al. (2015) that compared EMDR with trauma-focused CBT for PTSD, symptom

reduction was significantly in favour of the EMDR treatment group (*SMD* -0.43, 95% CI [-0.86 to -0.01]). When examining symptom subscales, EMDR treatment was significantly better than CBT in the treatment of intrusion (*SMD* = -0.37, 95% CI [-0.68 to -0.06], $p < .05$) and arousal (*SMD* = -0.34, 95% CI [-0.68 to -0.01], $p < .05$) PTSD symptoms. However, when EMDR was compared to CBT for avoidance symptoms, neither treatment emerged as superior ($p = .10$). Similar to prior reviews, these findings must be cautiously interpreted given small sample sizes, heterogeneity among studies included, or lack of randomization in the included studies, and other methodological limitations. A particularly noteworthy observation from the review by Chen et al. (2015) was the encouraging evidence that combining EMDR with CBT to address PTSD symptom clusters of intrusion and arousal may yield better clinical improvement outcomes.

In the most recent systematic review and meta-analysis of psychological therapies for PTSD, Lewis et al. (2020) aimed to synthesize the proliferation of psychological therapy RCTs. This updated review provided quantitative synthesis of 114 RCTs of 8171 participants with twenty-nine defined psychological therapies evaluated, broadly categorized as trauma-focused CBT, EMDR, group CBT, and internet delivered CBT (Lewis et al., 2020). Overall, the strongest evidence of effectiveness was found for trauma-focused CBT frameworks (e.g., CBT + prolonged exposure, cognitive processing therapy) and EMDR. In total, 51 RCTs compared trauma-focused CBT interventions and showed greater PTSD symptom reductions at post-intervention ($N = 1380$, *SMD* = -1.32, 95% CI [-1.57 to -1.08], $p < .05$) compared to waitlist controls (WLC) or treatment as usual (TAU) groups (Lewis et al., 2020). Seven trauma-focused *group* CBT interventions demonstrated significant effect-size reductions in PTSD symptom severity ($N = 313$, *SMD* = -1.02, 95% CI [-1.26 to -0.78], $p < .05$) compared to WLC/TAU groups (Lewis et al., 2020). New to the literature was the inclusion of three online delivered trauma-focused CBT interventions providing preliminary evidence of a positive effect on PTSD

symptom improvement (*n* = 145, *SMD* = -1.08, 95% CI [-1.80 to -0.37]) compared to WLC/TAU groups (Lewis et al., 2020). When comparing active treatment groups, there was no evidence of a significant difference between CBT with or without a trauma focus (*k* = 5, *n* = 185, *SMD* = -0.10, 95% CI [-0.19 to 0.39]), and no significant difference was found between trauma-focused CBT and EMDR (*k* = 10, *n* =387, *SMD* = -0.17, 95% CI [-0.55 to 0.21]; Lewis et al., 2020). Limitations to this systematic review that must be taken into consideration include the combination of WLC/TAU as a comparison group, the small number of studies evaluating group-based or online intervention approaches, evidence of publication bias (e.g., overestimation of the effectiveness of CBT), and heterogeneity across study methods, intervention design, and populations examined. While this current review provides a comprehensive synthesis of the psychological therapies most strongly supported in RCTs, continued exploration of the acceptability of more scalable and accessible psychological treatment approaches such as group-based and online delivered treatment was highlighted as a priority.

Online Cognitive Behavioural Therapy for PTSD

As presented in Lewis et al. (2020), the majority of research examining psychological treatments for PTSD has predominantly focused on examining in-person treatment approaches. Timely access to in-person PTSD treatment is not always feasible given the growing wait-times for treatment, increasing costs, and lack of trained and qualified therapists, and greater personal commitment required for in-person treatment (Lovell & Richards, 2000; Simon et al., 2019). Internet-delivered CBT represents an attractive treatment alternative with the potential to offer an accessible, scalable, and cost-effective option for individuals with PTSD. However, at present, relatively little research has focused on the acceptability of online treatment for PTSD.

Recently, Gaebel et al. (2017) conducted a comprehensive scoping review of the literature (e.g., RCTs, non-RCTs, prior systematic reviews) of online mental health interventions for PTSD to establish evidence-based recommendations for the European Psychiatric Association. Included studies examined intervention effects, treatment approaches (e.g., CBT, expressive writing, stress-management), quality assurance metrics (e.g., attrition, satisfaction, therapeutic alliance), safety, and therapist-supported versus non-supported interventions (Gaebel et al., 2017).

In terms of clinical effectiveness, Gaebel et al. (2017) provided considerable evidence in support of online and mobile-phone intervention in reducing PTSD and co-morbid conditions of anxiety and depression. Specifically, a systematic review by Bolton and Dorstyn (2015) within the Gaebel et al. (2017) review, encompassing 11 online interventions, found a significant overall large effect size for PTSD (Cohen's $d = 1.05$) and depression ($d = 1.01$) symptom reductions among participants in online psychological interventions ($p < .05$). The largest RCT within the Gaebel et al. (2017) review compared a five-week online CBT intervention with a WLC condition among parents ($n = 228$) after pregnancy loss, and found significant treatment effects for PTSD symptoms ($d = 0.84$) and grief ($d = 1.02$) post-intervention (Kersting et al., 2013). Given that most studies had short duration intervention and follow-up periods, the sustainability of clinical effects over time are less clear.

Within the Gaebel et al. (2017) review, only two studies (5%) empirically examined the impact of therapist-supported online interventions on PTSD symptom improvements post-intervention. Among these, one pilot study by Possemato et al. (2010) compared therapist-supported versus self-managed online CBT interventions and saw large effect size reductions in PTSD symptoms in the therapist-supported group ($d = 1.40$, $p < .01$) and small-moderate effect size reductions in PTSD symptom severity in the self-managed group ($d = 0.41$, $p = 0.02$;

Possemato et al., 2010). In another study examining therapeutic alliance between participants and the therapist within an online intervention, findings revealed that a strong therapeutic alliance established early in treatment predicted better treatment outcomes at post-intervention ($\beta = 0.37$, $t = 2.81$, $p = .007$; Wagner et al., 2012).

Despite these encouraging results, many of the studies in Gaebel et al. (2017) scoping review reported high drop-out rates during follow-up ranging from 14 to 62 percent, with little indication of reasons for intervention withdrawal. For example, Wagner et al. (2012) examined an Arabic translation of an established online CBT intervention in Iraq and reported 62% attrition rate likely due to the unstable country conditions at the time of intervention. Where reported, reasons for stopping treatment were typically due to lack of time, current trauma exposure (e.g., death in the family), technical problems, and treatment preferences (e.g., burden caused by expressive writing treatment). In addition, none of the studies reviewed provided cost-effectiveness evidence, which is surprising given the emphasis on online-delivered interventions as low-cost alternatives in the literature. In relation to adverse events, only one study assessed the occurrence of adverse events in an RCT that compared trauma-focused CBT with an active control group and reported no differences in PTSD symptoms between groups ($p < .05$), and two participants reported adverse events (e.g., increased symptoms from pre-post treatment) in each treatment group (Gaebel et al., 2017; Spence et al., 2014).

Overall, this scoping review highlighted key evidence regarding clinical effectiveness and future research directions for online-delivered therapies. Perhaps most relevant to this dissertation was the recommendation that online interventions, particularly Internet-based CBT, and mobile applications for symptom management were effective in reducing PTSD symptoms and comorbid symptoms of depression, anxiety, and grief (Gaebel et al., 2017). Among their recommendations, Gaebel et al. (2017) note the need for long-term evaluations of efficacy in

online interventions. Furthermore, despite limited evidence for better treatment outcomes in therapist-supported interventions, both therapist-supported and self-administered online interventions were recommended given clinically significant effect size reductions in PTSD symptoms in both approaches (Gaebel et al., 2017). Finally, online CBT interventions were recommended as not only beneficial for war-associated trauma, but other community populations including women who experienced traumatic pregnancy loss, or breast cancer patients (Gaebel et al., 2017).

Despite encouraging findings in support of online CBT interventions, several gaps in the literature remain, limiting the generalizability of the findings. First, studies included in the Gaebel et al. (2017) review relied heavily on self-reported PTSD symptoms with few clinician-diagnosed populations. Second, many studies were small-scale pilot-based interventions. Third, none of the studies reviewed compared online interventions to traditional in-person treatment controls making it difficult to discern their comparative effectiveness. Fourth, the impact and extent of therapist-support on participant adherence and treatment outcomes remains unclear and warrants further exploration. Fifth, high attrition rates and lack of evidence regarding the long-term sustainability of treatment effects remain key areas for future exploration in the field.

Since the work of Gaebel et al. (2017), an updated systematic review examining 10 Internet-delivered CBT RCTs (n = 720 participants) for PTSD was published by Lewis et al. (2019). The majority of RCTs included in this review (60%) included a clinician-administered PTSD assessment, evaluated non-veteran traumatic events (70%), and included predominantly (90%) mixed-gendered samples (Lewis et al., 2019). In terms of treatment effectiveness, meta-analytic results revealed a significant reduction of PTSD symptoms at post-intervention in favour of the online CBT intervention (k = 8, n = 560, SMD = -0.60, 95% CI [-0.97, -0.24], p < .05) compared to WLC/TAU groups (Lewis et al., 2019). However, in three studies that included

follow-up examinations, they found no evidence that treatment effects were maintained after three or six months (Lewis et al., 2019). Among online RCTs that compared trauma-focused CBT to non-trauma-focused CBT (n = 4), results revealed greater PTSD treatment effects (k = 4, n = 177, *SMD* = -1.04, 95% CI [-1.57, -0.51], $p < .05$) for online trauma-focused CBT (Lewis et al., 2019). Secondary outcome measures of depression and anxiety saw significantly greater reductions in online CBT groups compared to WLC/TAU at post-intervention and at follow-up at less than six months (Lewis et al., 2019). No differences ($p > .05$) between online CBT and non-CBT interventions in PTSD symptom reduction were found and no subgroup analysis examining therapist-factors that may influence intervention effects were reported (Lewis et al., 2019). The findings from this review are not as strong as the reviews of in-person CBT discussed earlier in this dissertation, and include similar limitations of small sample sizes, heterogeneous intervention characteristics and study designs, and combined self-reported and clinically diagnosed populations. As discussed previously, direct comparisons between online-delivered CBT with in-person CBT are missing from the current literature. Future non-inferiority trials of online versus in-person, therapist-supported versus self-administered, and CBT-alone versus blended CBT interventions, would help identify comparisons and recommendations to first-line treatment approaches for PTSD.

Mindfulness-Based Interventions for PTSD

There is evidence from existing clinical trials that a subgroup of PTSD participants are treatment-resistant to cognitive-focused therapies (Bradley et al., 2005; Niles et al., 2018). Since PTSD presents significant challenges in emotion and arousal regulation, treatment approaches that emphasize self-regulation of bodily sensations represent a viable additional treatment option. Mindfulness meditation represents one of such approaches that has gained traction in the last two

decades. Having its origin in the Buddhist tradition, mindfulness meditation refers to moment-to-moment focal attention and non-judgemental awareness of thoughts, emotions, and bodily sensations in the present moment (Bishop et al., 2004; Kabat-Zinn, 2003a; Lutz et al., 2008). While specific mindfulness practices vary, the most empirically-supported therapeutic programs include mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1982), mindfulness-based cognitive therapy (MBCT; Segal et al., 2018), acceptance and commitment therapy (ACT; Hayes et al., 2012), and, more recently, mindfulness-based cognitive behavioural therapy online (MBCBT-0; Ritvo et al., 2021). Indeed, mindfulness-based interventions have demonstrated to be effective in reducing anxiety symptoms, depression symptoms, preventing depressive relapse, and enhancing emotional regulation in both non-clinical (Chiesa & Serretti, 2009; Fjorback et al., 2011; Gotink et al., 2015; Regehr et al., 2013) and clinical populations (e.g., cancer, diagnosed depression, and anxiety; A-Tjak et al., 2015; Blanck et al., 2018; Cramer et al., 2012; Gotink et al., 2015; Hofmann et al., 2010; Ritvo et al., 2021; Sipe et al., 2012).

In relation to mindfulness-based interventions in the treatment of PTSD, Hopwood & Schute (2017) systematically reviewed 18 randomized clinical trials consisting of 1219 participants examined. Overall, findings suggested a significant moderate effect (Hedges' g = -0.44, $p < .001$) on PTSD symptom reduction in mindfulness-based interventions compared with control conditions (Hopwood & Schute, 2017). Additional meta-regression analyses revealed intervention duration (in hours) was associated with the magnitude of PTSD symptom reduction (Hopwood & Schute, 2017). Furthermore, longer mindfulness-based interventions were associated with greater reductions in PTSD symptom severity, indicating the possibility of a dose-response relationship (Hopwood & Schute, 2017). While non-significant between-group effects were found, mindfulness-based interventions that that were trauma-specific trended towards a stronger effect on PTSD symptom reduction (Hedges' g = -0.57) compared to

mindfulness-based interventions that were not trauma-specific (Hedges' g = -0.35). Overall, the findings from Hopwood & Schute (2017) support mindfulness-based interventions to be an effective treatment for PTSD symptoms. What remains to be seen, however, is whether the combination of mindfulness with existing CBT frameworks, both in-person and online, would yield even greater PTSD symptom than stand-alone treatments.

Online Mindfulness-Based Cognitive Behavioural Therapy Interventions

Meta-analytic reviews of established internet-based cognitive behavioural interventions (e.g., CBT, ACT) have focused predominantly on depression and anxiety and have found that online delivery has nearly equal effects to traditional in-person approaches (Andersson et al., 2011; Andersson & Cuijpers, 2009). What remains unclear is whether online interventions that combine mindfulness meditation with internet-based cognitive behavioral psychotherapies like CBT or ACT may potentially yield improved results in symptom reductions among clinician-diagnosed populations. Current meta-analytic reviews of online mindfulness-based cognitive behavioral interventions explore outcomes for *general* populations that self-report anxiety or depression and show relatively similar effects to online stand-alone CBT and face-to-face mindfulness (Cavanagh et al., 2014; Fish et al., 2016; Spijkerman et al., 2016). Unfortunately, these reviews limit our understanding of the *clinical relevance* of treatment effects generally given the blend of non-clinical and clinically-diagnosed populations (Spijkerman et al., 2016) heterogeneity in treatment delivery format (e.g., hard-copy materials vs. stand-alone online delivery; Cavanagh et al., 2014), varied treatment methodologies employed (Fish et al., 2016), and lack of PTSD populations sampled. While these authors have made significant contributions to the understanding of online therapeutic interventions that use mindfulness components, there is a need for focused research on the utility of multi-modal (e.g., CBT + mindfulness) treatment

interventions for clinician-diagnosed populations to help refine diagnostic treatment options and assist the provisions of treatment that improve patient-specific outcomes for PTSD specifically.

The effectiveness of online CBT with mindfulness meditation prescription for clinically-diagnosed PTSD is currently unknown and has not been evaluated in the literature. According to Sareen (2014), approximately 90% of people diagnosed with PTSD will develop at least on comorbid psychiatric condition such as major depressive disorder or generalized anxiety disorder in their lifetime. Thus, a systematic review and meta-analysis conducted by Kirk et al. (in press) evaluating the effectiveness of online psychotherapeutic interventions which included a mindfulness component in reducing depression and anxiety in clinically-diagnosed samples provides the best known supportive literature (See Appendix A for manuscript). Overall, 11 studies were reviewed, and meta-analytic findings revealed a moderate effect for reductions in depression (d = -0.47) and anxiety (d = -0.40) in favour of the mindfulness-based intervention groups ($p < .05$). According to Button et al. (2015), a minimal clinically important difference (MCID) in depression symptoms refers to a 17.5% change. Based on this criterion, findings from Kirk et al. (in press) revealed a three-fold mean reduction of nearly 46% in depression symptoms from baseline to post-intervention among the treatment groups suggesting that hybrid psychotherapeutic treatments that include mindfulness may be an important component for future online clinical treatment approaches.

The review by Kirk et al. (in press) demonstrated superior findings compared to a review of 13 RCTs by Karyotaki et al. (2017) examining self-guided, internet-linked CBT. While these findings are notable for future clinical best-practice, the question arises about whether there are added benefits when CBT interventions are combined with mindfulness *and* therapist-support? While the Karyotaki et al. (2017) review and the Kirk et al (in press) support the efficacy of online cognitive behavioral interventions, it is challenging to ascertain the relative value of these

respective interventions (i.e., online mindfulness-based cognitive behavioral vs. self-guided, internet-linked cognitive behavioral). In terms of mean effect size per studies reviewed (n = 13 in Karyotaki et al. (2017) and n = 7 in Kirk et al. (in press), Karyotaki et al. (2017) reported a mean Hedges g = -0.27 (small effect) for reduction of depressive symptom severity while our calculations yielded an even greater (moderate) effect Cohen's *d* = -0.47, pointing to the added benefits of including mindfulness and therapist-support as important adjuncts to online therapeutic treatments for clinically-diagnosed populations. Similar limitations as seen in prior reviews (e.g., small sample sizes, attrition challenges, heterogeneity, lack of waitlist control) limit the generalizability of the findings in the review conducted by Kirk et al. (in press), especially the relevance to clinical PTSD. However, the findings highlight the need for continued focused research examining the effectiveness of combining CBT with mindfulness compared to stand-alone treatment approaches.

Yoga Interventions for PTSD

Given difficulties with emotion regulation, impulse regulation, and hyperarousal in PTSD, mindfulness meditation alone may be difficult for those with PTSD without guidance from a trained practitioner to help enhance attention focus (van der Kolk, 2015). A physical practice like yoga, aimed at uniting the body *and* mind may be an effective treatment in addition to traditional methods in addressing PTSD symptomatology. Yoga, an ancient Hindu practice, has increasingly been applied as a therapeutic modality for a wide variety of physical and mental health conditions due to the effects on modulation of the autonomic nervous systems, stimulation of the limbic system and activation of the antagonistic neuromuscular system (Tyagi & Cohen, 2016). The heightened awareness of the body during a yoga session can help individuals detect key physical sensations (e.g., body tension, irregular heart rate, shallow breath) and provide

information on how these sensations are linked to emotional triggers related to trauma (van der Kolk et al., 2014). While many styles of yoga exist (e.g., Hatha, Yin, Kundalini), the practice as a whole has been described as 'mindfulness meditation in motion'(Salmon et al., 2009), by combining controlled breathing techniques (*pranayama*), mindful movement through specific postures (*asanas*), energy awakening (*chi*), and focused attention on the present moment (*dhyana*; Gangadhar & Varambally, 2011; Kessler et al., 2001). Therefore, given the integration of mindfulness and awareness of bodily sensations in the yoga practice, it is hypothesized that the practice of yoga could enhance emotion regulation, as a result of the nonjudgmental awareness of the present moment experience, and reduces hyperarousal by downregulating the "fight or flight" response (Tyagi & Cohen, 2016). As a result, yoga represents an important practice to modify the maladaptive psychological and physiological processes that sustain PTSD symptoms.

Prior reviews of RCTs have supported the overall effectiveness of physical activity interventions (e.g., walking, strength training) as an effective approach in reducing PTSD symptoms (Cabral et al., 2011; Kirkwood et al., 2005; Rosenbaum et al., 2015). More recently, a systematic review conducted by Taylor et al. (2020) examined stand-alone mindfulness and yoga-based interventions for psychological trauma. Overall, 12 mindfulness, 10 yoga, and 2 integrative (yoga + mindfulness, tai chi or qi gong) RCTs met meta-analytic inclusion criteria and were assessed in the review, and results revealed an overall significant, pooled effect for these interventions in reducing PTSD symptoms ($g = .51$, $p < .001$). When examining program types independently, similar statistically significant effects were found for both stand-alone mindfulness ($g = .45$, $p < .001$) and yoga programs ($g = 0.46$, $p < .001$). Interestingly, despite being based on the results of only 2 studies, integrative exercise programs (e.g., yoga + tai chi) had a more meaningful effect on PTSD symptom reduction (Hedges' $g = .94$, $p < .001$) with an

overall large effect (Taylor et al., 2020). When compared to reviews of physical activity and PTSD, findings from Taylor et al. (2020) suggest that integrative movement interventions (e.g., mindfulness + yoga + tai chi) may yield even greater reductions in PTSD symptoms (Hedges' g = -0.51) than other traditional (e.g., walking, strength training) forms of physical activity (Hedges' g = -0.35; Rosenbaum et al., 2015). The studies reviewed by Taylor et al. (2020) provided promising evidence of effectiveness for mindfulness-based interventions, despite variations in PTSD diagnostic criteria and outcomes, intervention protocol, and a heavy focused on combat-related trauma. Future studies would benefit from an exploration of combining yoga with existing CBT treatments, evaluations of online delivery methods, and the use of objective measures (e.g., heart rate variability, pupillometry) to assist in understanding the neurophysiological mechanisms involved in PTSD development/formation and symptom reduction.

Mindfulness-Based Interventions for PTSD, Pupillometry and HRV Effects

While mindfulness-based practices have become increasingly relevant in the treatment of psychiatric conditions, research examining the effects of these interventions on the psychophysiology (e.g., HRV) of clinically diagnosed PTSD participants is limited. For example, a pilot study conducted by Bhatnagar et al. (2013) examined the effects of an 8-week MBSR intervention on PTSD and HRV in eight combat veterans (male n = 7; 100% Caucasian). A clinically significant reduction in PTSD symptoms (CAPS M = -14.8, SD = 4.8, $p < .05$) was found. HRV data was captured for five of the eight (62.5%) participants. The authors indicated that parasympathetic functioning increased for all five participants, but outcome measures and significance values were missing. No description of outcome measures or reporting of statistical analysis data was provided in the publication making HRV interpretation unavailable (Bhatnagar

et al., 2013). Another study conducted by Wahbeh et al. (2016) evaluated three mechanistic pathways of mindfulness meditation by examining four different 6-week interventions in combat veterans with PTSD. A total of 102 participants were randomized to 6-weeks of a) mindfulness meditation body scans, b) slow breathing with biofeedback, c) mindful breath awareness, or d) sitting quietly conditions. Weekly sessions were guided and lasted 20-minutes. Self-reported PTSD symptoms, autonomic function (e.g., ECG), prefrontal cortex activity (e.g., EEG), respiration and salivary cortisol were collected pre-post intervention. In terms of the mindfulness meditation condition, significant within-group differences were found for PTSD symptom reduction ($t_{23} = 2.10$, $p > .05$). No significant between group differences in PTSD symptoms were found. In terms of HRV, no significant between-group or within-group changes in HRV were found pre-post intervention period ($p > .05$). Mindfulness meditation participants were the only group who showed significantly lower morning cortisol values after the intervention ($t_{22} = 1.9$, $p = 0.05$). While this study is supported with a large sample size and combined psychometric and psychophysiology data, limitations include short intervention duration, lack of blinded assessments, risk of bias, and unequal home practice prescription between arms.

To our knowledge, only one study has examined both pupillary reactivity and heart rate variability (HRV) effects among a generally healthy population of meditation practitioners (Vasquez-Rosati et al., 2017). In this cross-sectional study, the authors aimed to determine if changes in pupil diameter would serve as a reliable physiological marker of emotional processing in meditation practitioners (2-15 years practice of 15 min daily and two 60 min sessions per week at a local meditation centre), and as a predictor of meditation practice. Pupil diameter fluctuations in mindfulness meditation practitioners were compared to non-practitioners after exposure to emotionally-valent images (e.g., neutral, threatening, happy). Correlations between pupillometry and HRV were also evaluated to further understand associations between

these two autonomic markers during meditation. The results revealed distinct pupillary reactivity with respect to negative emotional images. Specifically, meditators showed a significantly prolonged, stronger pupil contraction response (M = -0.53nu) compared to non-meditators (M = -0.36nu, p = .02) reflecting diminished sympathetic (noradrenergic) response among meditators (Vasquez-Rosati et al., 2017). Meditation practitioners also showed significantly faster physiological recovery to baseline pupillary state suggesting that mindfulness-based practice modulates the autonomic nervous system response, including emotional responses and recovery (Vasquez-Rosati et al., 2017). Logistic regression analysis revealed that pupil reactivity (e.g., maximum pupil contraction size) was a significant predictor of mindfulness practice (β = −9.84, p = 0.03). Those who had smaller pupil contraction size were more likely to be a meditator. No significant between- or within-group modulation of HRV was found based on the presentation of different emotional images, however basal heart rate was significantly lower among mindfulness practitioners compared to non-meditators (p = 0.009; Vasquez-Rosati et al., 2017). Methodological limitations of this study included: a) cross-sectional non-intervention study design, b) small sample size (n = 11 meditation practitioners; n = 9 non-meditators), c) variability in meditation practitioner eligibility criteria, and d) no pre-post measures to examine physiological changes over time in relation to meditation practices. Despite these limitations, these findings provide preliminary evidence in support of pupillometry as a method to assess mindfulness-related autonomic regulation patterns.

Summary of the Literature

Within a Canadian context, young adults ages 18-35 years, who have been exposed to trauma, are an important target population for therapeutic intervention. Given the heavy demands and complex life transitions experienced during this time period, stigma surrounding symptom

disclosure, and growing waitlists for in-person treatment, young adults with PTSD are at risk of being undertreated. After extensive review of the literature, there is evidence indicating that mindfulness, yoga, and CBT are effective stand-alone therapeutic modalities in the reduction of self-reported PTSD symptoms and the regulation of autonomic function, a common characteristic of PTSD. However, the majority of studies used non-clinical (e.g., generally healthy) or veteran-only populations, lacked objective measures of autonomic function, and varied in intervention duration and design. To our knowledge, no known interventions have integrated all three therapeutic approaches of CBT, mindfulness and yoga (CBT-MY) in an online delivery format using a combination of well-validated and reliable self-report measures of PTSD or combined objective pupillometry and HRV measures in a pre-post experimental design to understand the impact on autonomic function. Thus, empirically based conclusions about the impact of evidence-based online PTSD interventions on autonomic function remain largely undetermined. Therefore, an evaluation of an online CBT-MY intervention for young adults with PTSD appears an important priority for clinical PTSD treatment research.

Chapter 3: Methodology

The purpose of this chapter is to introduce the research methodology employed to guide the development and implementation of this registered single-arm experimental clinical trial. The study purpose, research questions and hypotheses, study participants, procedures, measurement and instrumentation, and statistical analysis plan are presented.

Study Purpose

The purpose of this study was to evaluate the effectiveness of an 8-week CBT-MY intervention in reducing self-reported PTSD symptoms and autonomic dysregulation among young adults, ages 18-25 years, with PTSD. This study expands the existing literature examining multiple objective markers of autonomic regulation in evaluating intervention results for clinically diagnosed individuals and comparing differences and similarities between two theoretically linked objective measures.

Study Research Questions

Since there is a paucity of research examining the combined psychometric and objective outcomes in response to an online CBT-MY intervention, a quantitative research design was employed to determine preliminary effect sizes for future definitive randomized controlled trials. Research questions guiding this dissertation were descriptive and including the following:

RQ1: Does an 8-week online CBT-MY intervention have a significant effect on self-reported symptoms of PTSD?

RQ2: Does an 8-week online CBT-MY intervention have a significant effect on associated mental health symptoms of depression, anxiety, pain and mindfulness?

RQ3: Do psychophysiology measures of pupil response and HRV differ after exposure to

varying emotional stimuli during a 25-minute protocol consisting of baseline rest, emotional image stress task, and guided meditation?

RQ4: Does an 8-week online CBT-MY intervention have a significant effect on psychophysiology measures of pupil response and HRV?

RQ5: Do PTSD participants show significantly different patterns of pupil response and HRV when compared to cross-sectional data of a convenience cohort sample of non-PTSD-affected individuals with no history of mental health conditions?

RQ6: What is the relationship between autonomic function measures of peak pupil dilation and HRV among PTSD participants across a 25-minute protocol consisting of rest, stress and meditation?

Exploratory Research Questions

An additional exploratory research question was examined in this dissertation:

EQ1: Do certain baseline mental health profiles (e.g., PTSD + severe depression) explain the variance in baseline PTSD symptom severity?

EQ2: Do certain mental health profiles (e.g., PTSD + severe depression) moderate psychophysiology measures before and after an 8-week online CBT-MY intervention?

Hypotheses

In relation to psychometric outcomes, it was hypothesized that PTSD participants would show clinically meaningful reductions in PTSD symptom severity at post-intervention, defined as a minimum reduction of 10 points on the CAPS-5 (Stefanovics et al., 2018). We hypothesized clinically meaningful reductions of a minimum of 17.5% in depression severity, based on recommendations by Button et al. (2015), and applied this same threshold to PTSD, anxiety, pain and trait mindfulness at post-intervention. From a psychophysiology standpoint, it was

hypothesized that both pupillometry and HRV indices would significantly improve at the end of the 8-week intervention. When compared to a single time point of cross-sectional data of a convenience sample of non-PTSD participants, it was hypothesized that PTSD participants would show significantly lower HRV and higher pupillometry outcomes at baseline, but these would be non-significant after the 8-week intervention. Exploratory objective analyses examined the mental health profiles of those who saw the greatest treatment effect to help establish direction for targeted clinical research.

H1: *Clinically significant reductions in CAPS-5 scores, defined as a minimum reduction of 10 points* (Stefanovics et al., 2018)*, are expected at post-intervention.*

H2: *Clinically significant reductions, defined as a reduction of 17.5%, in scores* (Button et al., 2015)*, on the PCL-5, BDI-II, BAI, PCS and BPI are expected at post-intervention.*

H3: *Participants who complete the intervention will report clinically significant (p <.05) increases in the Five Facet Mindfulness Questionnaire (FFMQ) scores.*

H4: *Significant change in HRV and pupillometry across the 25-minute lab protocol of rest, stress, and meditation are expected. Compared to rest, HRV is expected to significantly decrease during the stress phase and increase during meditation. Peak pupil dilation (PPD) is expected to significantly increase during stress and decrease during meditation.*

H5*: Significant overall reductions in PPD and increases in HRV are expected at post-intervention.*

H6: *PTSD participants are expected to show significantly lower HRV and increased PPD at baseline measures only compared to cross-sectional data of a convenience sample of non-PTSD participants. Post-intervention outcome measures will be non-significant.*

Study Design

This study was a registered, single-arm experimental clinical trial (www.clinicaltrials.gov ID: NCT03684473) that follows the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Schulz et al., 2010). A convenience, university-based sample of adults, between 18 and 25 years of age, with no history of clinical mental health diagnosis or treatment was used to differentiate measurements of autonomic function (i.e., PPD and HRV). This registered clinical trial met the requirements for ethical approval by the York University Human Participants Research and Ethics Committee prior to commencement.

Participants

Intervention participants were adults, between 18-35 years, who were enrolled at York University, Toronto, Canada. All participants self-reported exposure to at least one traumatic event and met a clinical diagnosis of PTSD measured by the Clinician Administered Posttraumatic Stress Scale (CAPS-5; Weathers, Blake et al., 2013) or threshold symptoms on the PTSD Checklist for *DSM*-5 Civilian Version (PCL-5; Weathers, Litz, et al., 2013). A convenience sample of university students with no self-reported prior history of clinical mental health diagnosis or treatment were recruited from an undergraduate research pool for comparisons of physiological measures of autonomic function. For the convenience cohort, measures were collected at a single time-point using a modified version of a previously validated 25-minute computer-based protocol (Azam et al., 2015, 2016).

Inclusion and Exclusion Criteria

Participants were eligible to participate if they indicated exposure to one or more lifetime traumatic events based on the self-report Life Events Checklist for *DSM-5* (LEC-5; Weathers,

Blake, et al., 2013) and met *DSM-5* diagnostic criteria for PTSD based on the Clinician Administered Posttraumatic Stress Scale (CAPS-5; Weathers et al., 2018) or PTSD checklist for *DSM-5* civilian version (PCL-5). Exclusion criteria included current/ongoing trauma (e.g., current physical or sexual abuse), unstable medical comorbidity (e.g., epilepsy), active suicide risk/self-harm, pregnancy/breastfeeding status, current drug/alcohol addiction, current psychological treatment, yoga attendance within the last month, and no internet access. For pupillometry and HRV testing, participants who reported oculomotor nerve palsy, corrective lenses prescription that was +/- 4.0, or current use of opioids, anti-hypertensives, or epinephrine were excluded from the eye-tracking and HRV procedures since these conditions affect pupil and HRV response.

Justification of Sample Size

An *a priori* power calculation was conducted based on $\mathbf{H_1}$ to detect a Minimal Clinically Important Difference (MCID; Stefanovics et al., 2018) reduction in PTSD symptom severity (i.e., reduction of symptoms by a minimum of 10 points, or a change in *z*-score by 0.8 standard deviations; Stefanovics et al., 2018) measured by the CAPS-5 ($p < .05$). The power analysis based on a Cohen's (1988) large effect size ($d = .80$), power of 0.8, and an alpha set to $p < .05$ (correlation among factors $r = .50$) was conducted. From this analysis it was determined that a minimum sample size of 15 participants would provide ample testing power (Cohen, 1988; Erdfelder et al., 1996). Considering a 20% attrition rate ($n = 3$) in the study, we over-enrolled participants to allow for attrition, setting the final recruitment target at 18 participants to detect within-group differences based on the pre-post design for H_1 (Erdfelder et al., 1996; Faul et al., 2007).

Few published studies provide empirically-supported criteria for determining whether statistically significant changes in CAPS-5 scores are clinically meaningful. Stefanovics et al. (2018), conducted data analysis on a randomized clinical trial of antipsychotic medication in military-related treatment resistant PTSD (N = 267) and determined the MCID for the previous version of the CAPS (CAPS-4) based on the *DSM-IV*. Based on this study, a MCID change in symptom severity standardized *z*-score ranged from 0.5 to 0.8 standard deviations. This translates to an estimated reduction of 5.4% to 9.8% in the total symptom severity score, with a median of 7.6% (Stefanovics et al., 2018). A meta-analysis, examining the effectiveness of psychotherapeutic approaches for PTSD, used a MCID reduction of 10-12 points on the CAPS-4 symptom severity score (7.4% to 8.8% reduction) as a standard of meaningful improvement, but provided no empirical rationale for this estimate (Steenkamp et al., 2015). The authors reviewed a total of 27 studies and when compared to Stefanovics et al (2018) calculations, 19 (70.4%) of the studies showed clinically meaningful improvement in PTSD symptoms using the criteria, suggesting it was a useful benchmark. Similarly, a randomized clinical trial of trauma-focused group therapy for PTSD among 360 male veterans found a clinically meaningful reduction on the CAPS-4 symptom severity score by 7.4% (estimated 10 points) which yielded a moderate effect size of d = 0.5 (Schnurr et al., 2003). For the purposes of this study, a MCID on the CAPS-5 total symptom severity score will be considered a change in raw scores by 0.8 standard deviations or 10-point reduction in CAPS-5 total symptom severity score.

Procedures

Recruitment Procedure

Ethics approval was obtained prior to study implementation and recruitment commenced in June 2018 through to December 2019 at York University using multimodal convenience and

purposive sampling techniques. On-campus classroom visits to mental health clubs or psychology classes to promote the study, posters and flyers displayed in public forum boards (See Appendix B), university newspaper advertisements, and interviews on student-run podcasts were conducted in an attempt to recruit interested participants. Interested participants were invited to email the study coordinator directly and were sent a 5-minute pre-screen survey to assess initial eligibility (e.g., trauma exposure, current symptoms, suicide ideation). Participants who expressed interest in study participation via recruitment strategies and provided email contact information were contacted by the primary investigator following the Dillman (2007) Tailored Design Method to achieve a maximum response rate (80% response rate) through standardized multiple contacts. Interested participants were sent three emails which included an initial thank-you and a pre-screening online survey link to assess initial exclusion criteria (e.g., current trauma, addiction, self-harm, suicide ideation), a follow-up reminder with the pre-screening online survey link and a copy of informed consent form to review, and a thank-you email and final invitation reminder (Dillman et al., 2014).

Screening Procedure for Trauma Exposure and DSM-5 PTSD Symptoms

Participants who met inclusion criteria were invited to a 90-minute in-person meeting to discuss the study, further assess PTSD symptoms, and provide informed written consent (See Appendix C). During the meeting, participants were screened for trauma exposure and then assessed for the presence and severity of PTSD symptoms using the CAPS-5 interview. Participants were asked to suspend current psychotherapy with a psychologist, but psychiatric treatment (e.g., prescription medications and psychiatry appointments) were allowed for the duration of the 8-week program. Within one-week of the CAPS-5 interview, participants were asked to complete an online demographic and psychometric questionnaire to provide baseline

(T1) measurements of psychological variables (e.g., PTSD, depression, anxiety) and to schedule an in-person lab assessment to provide psychophysiological (e.g., pupillometry and HRV) variables. The lab assessment was not conducted on the same day as the CAPS-5 interview because of the potential for elevated baseline stress due to trauma exposure disclosure and related symptoms. After the lab assessment was completed, the study coordinator discussed the intervention in detail, provided a free yoga mat, and scheduled the first counselling call within 1-week. Psychometric data was collected at two-time points for the PTSD intervention participants: baseline (T1) and post 8-week intervention (T2).

Recruitment Procedure of Convenience Cohort Non-PTSD Sample

A convenience sample of university students, ages 18-35 years, with no prior history of clinical mental health disorders were recruited from the York University undergraduate psychology research participant pool for comparisons of objective physiological measures of autonomic function (e.g., pupillometry and HRV). Eligible participants booked a single lab assessment to provide non-PTSD comparison data. The non-PTSD participants only completed the lab assessment at one time-point and were not given the intervention program. Participants completed the identical 25-minute computer-based protocol as completed by the PTSD participants. Primary outcome data for non-PTSD participants was cross-section and collected at one time-point: baseline (T1).

Lab Assessment Procedure

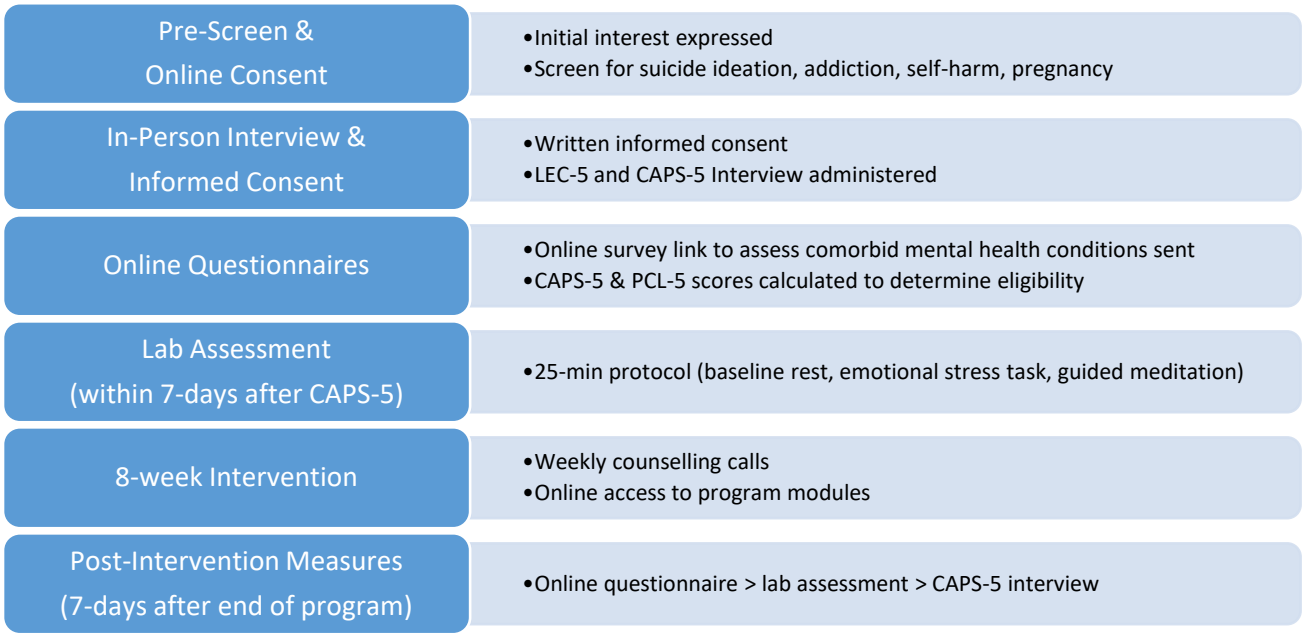
Participants were attached to an electrocardiogram (ECG) unit, a respiration belt and also wore Tobii Pro T60XL Glasses 2.0 (for pupillometry recordings) for the duration of the 25-minute computer task protocol. Autonomic nervous system response was assessed via pupillometry and heart-rate-variability (HRV) using a modified version of a previously validated

25-minute computer protocol (Azam et al., 2015, 2016) comprising a 5-minute baseline resting phase, a 10-minute artificial stress phase, and a 10-minute pre-recorded guided meditation relaxation phase. The modifications included replacing the cognitive stress task with an emotional image stress task (EST) using 60-images from the International Affective Picture System (IAPS) database reflecting fear, sadness, anger, or frustration to evoke autonomic activation. The guided meditation followed the same script as previously validated (Azam et al., 2015, 2016) with the exception that the voice was of a female meditation facilitator to alleviate the potential for retriggering of emotions by female sexual assault survivors of male perpetrators. During the baseline and meditation phases, participants viewed a moving fixation cross on a computer screen that randomly changed locations in a 9-square grid every 10-seconds. For the stress phase, a series of 60 negative emotional images from the International Affective Picture System (IAPS) were presented consecutively at 10-seconds intervals. Based on safety considerations, all images were carefully screened and approved by the clinical psychologist supervising this clinical trial. Images that met the lowest pleasure ratings or highest arousal ratings were excluded. Each of the emotional images were original colour images set at the same height of 16.51cm high and 20.32cm wide. The computer screen luminance was set to night settings with blue light removed and brightness standardized and set at 60%. Immediately following the emotional imaging stress task participants listened to a 10-minute guided meditation through noise cancelling headphones. The meditation audio featured mindfulness instructions that emphasize bringing attention to breathing sensations. If participants became distracted by thoughts, feelings and/or external stimuli, they were guided to a non-judgmental refocusing on breathing sensations (Azam et al., 2015, 2016). Participants were instructed to keep their eyes open and fixed on the fixation cross during the meditation. The protocol was conducted in a standardized dimly lit environment (e.g., lux = 71) and sound attenuated room

using noise cancelling headphones. A chin rest located 65cm away from the computer screen was used to standardize pupillometric measurement conditions. Participants were instructed to refrain from making sudden movements, to maintain eye fixation, and to remain silent. At the end of the 8-week intervention, the lab assessment was completed within one week of program completion (T2). The sequence of participant procedures is shown in Figure 2.

Figure 2

Sequence of Procedures Followed by Participants throughout the Study Protocol



Intervention: CBT-MY Program with Therapist Support

The eight-week CBT-MY intervention started the day after the baseline lab assessment. Each participant received password protected online access to the online program materials (www.healmytraumaimprint.com). The CBT-MY intervention was designed and developed by the doctoral student undertaking this dissertation (MKC) at York University, who is a Canadian Yoga Alliance Registered Yoga Teacher with specialized training in trauma-sensitive yoga facilitation. The entire intervention was supported by weekly phone-based CBT counselling and

was structured around eight CBT-themed weekly modules related to healing from PTSD. The weekly counselling sessions and the guided mindfulness and yoga videos were specific to the weekly module themes (see Table 4).

Table 4

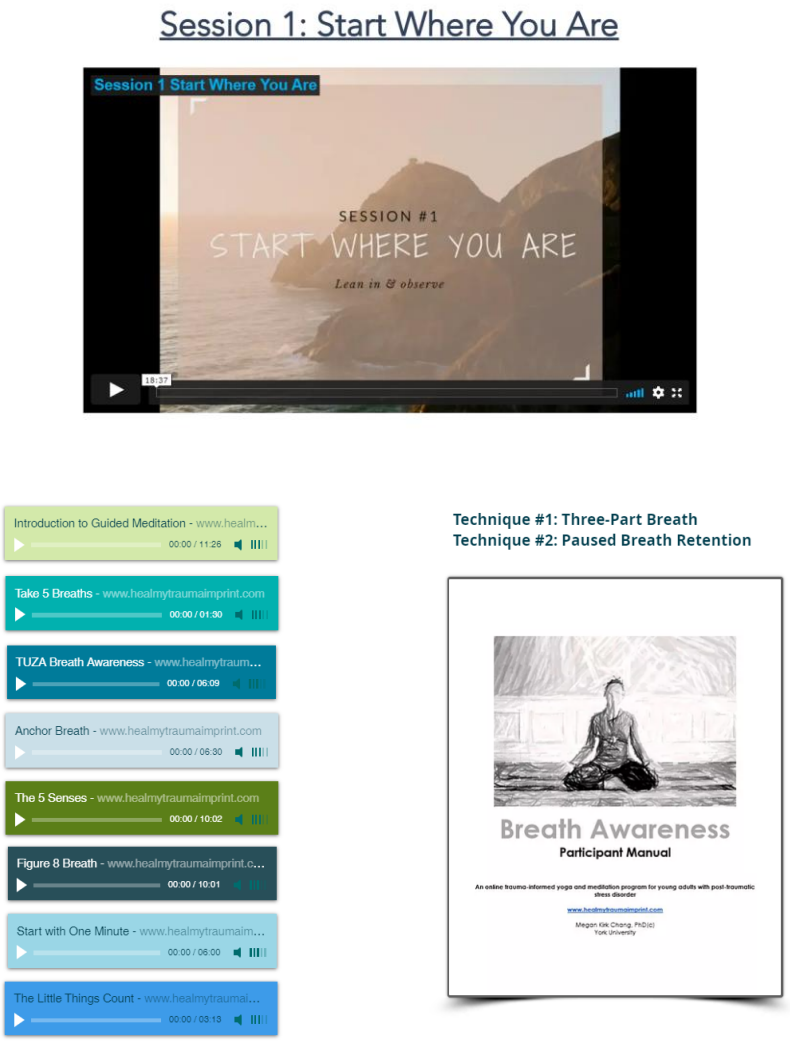
Weekly Module Themes in CBT-MY Program

Module Topic	Major CBT-MY Themes
1. Start Where You Are	- Present-moment awareness of bodily sensations, emotions and thoughts without judgement, discovering the fragmented self - Mindfulness of avoidance and distractions - Mindfulness of breath as an anchor to cultivate calm
2. The Ebb & Flow	- Challenging beliefs on what healing should look like - Cultivating acceptance of the ebb and flow of healing - Leaning into uncertainty, neutrality, and patience
3. Your Body Has Your Back	- Perspective shifting of bodily sensations and learning to sense the inner messages of the body - Recognition of body cues; discernment of stress-response versus calm arousal - Befriending the body with compassion
4. Emotional Triggers	- Addressing rumination, worry, and fear - Understanding reactivity vs. responding - Mindfulness of habitual negative thoughts, self-awareness, and knee-jerk reactions
5. Holding Space for Suffering	- Stress vs. trauma response in the body; dorsal vagal shut-down, dissociation, chronic hypervigilance - Mindfulness for self-regulation and emotion regulation
6. The Second Arrow	- Uncovering cognitive distortions and negative self-talk - Addressing shame, the Shadow Self and fragmented self - Mindfulness as a tool for integrations of all ‘selves’
7. Towards Forgiveness	- Discovering mindfulness as a tool for self-compassion and compassion for others - Understanding forgiveness through mindful breath to release and let go
8. Facing Forwards	- Cultivating inner peace, moving towards posttraumatic growth, resilience - Rebuilding trust with inner sources of wisdom, mindfulness for communication, and authentic connection with self

Participants were encouraged to complete a daily practice pertaining to one module theme per week to avoid burnout. When participants signed on to the program platform, each module contained three parts: 1) Access to seven guided mindfulness meditations (ranging from 5-10 minutes each) that focused on breath awareness, body scan, progressive relaxation, and body awareness techniques; 2) A weekly 20 min trauma-informed yoga video that differed each week, and 3) a 2 min daily mindful breath technique (e.g., three-part breath, paused-breath retention; see Figure 3).

Figure 3

Example of Online CBT-MY Program Module for Participants



Trauma-Sensitive Mindfulness and Yoga Protocol

The trauma-sensitive intervention protocol focused on the home-based self-directed practice of mindfulness meditation and yoga. Eight weeks was chosen as the preferred duration of the intervention for three reasons: 1) it aligns with prior evidence-based mindfulness-based treatment programs lengths of 8-weeks (Kabat-Zinn, 2003a; 2003b), 2) takes into consideration the 14-week academic semester system at York University, and 3) it takes into consideration the single-arm experimental trial intention of providing evidence to support longer duration randomized clinical trials. The yoga intervention was developed by a 250-hour certified and registered Canadian Yoga Alliance (CYA) Hatha-Vinyasa yoga teacher with additional specialized 30-hour in-person training in Trauma-Sensitive Yoga Training (Emerson & Hopper, 2011) from the Justice Resource Institute (www.jri.org), Boston, MA, USA (Emerson & Hopper, 2011). The eight-week program followed a modified existing protocol (van der Kolk et al., 2014) and was supervised by a registered clinical psychologist with expertise in mindfulness-based psychotherapy for mental health disorders to ensure additional mental and emotional support was provided to participants who experienced a retriggering of PTSD symptoms. The foundation of the yoga program was built upon traditional Hatha-Vinyasa yoga postures that include breath awareness, movement, and meditation. The Trauma-Informed component of the program takes into consideration language, exercises, teacher qualities, and physical assists (Emerson & Hopper, 2011). In terms of language, the yoga instruction was non-directive, and provided full choice and control of the participant through invitational language such as, “when you are ready” or “if you like” before each body posture cue (Emerson & Hopper, 2011). The entire yoga program used simple, English language designed to be clear and concise with no misleading interpretation. Neither metaphors nor Sanskrit terms for yoga postures were used in order to ensure that the participants’ comfort level and comprehension was emphasized. Based on

training in Trauma-Informed Yoga best practices (Emerson & Hopper, 2011), a foundation of yoga postures (with variations) were used during each 20-min recording and varied week to week to provide choice, flexibility and variety (see Table 5). For example, in Week 1, the yoga session included neck roles, shoulder circles, tabletop, reclining twist, full-body stretch and breath awareness (see Table 5).

Table 5

Trauma-Sensitive Yoga Foundational Movements

Yoga Posture	**Possible Variations**	**Purpose**
Full-Body Stretch	Standing, lying down	Awakening; body awareness; release of tension and hyperarousal; empowering; body sensing and setting boundaries
Mountain Pose	Seated, Standing; with/without twists	Grounding, centering, balancing, helps prevent dissociation; empowering, builds confidence
Breath Awareness	Breath control, breath retention, figure "8" breath pattern	Grounding, balancing, awareness, feeling off-balance, decreasing hyper- and hypoarousal
Sun Salutation A	Sun breaths, arm-movement only	Energizing, empowering, present moment awareness, decreases numbing, low energy or feeling shut down; helps overcome feeling stuck and indecisive
Neck roles	Half-circle; full circle; side stretch; front/back stretch	Decreases hyperarousal and feelings of anxiety, tension, fear
Shoulder Circles	Forward/Backward; up/down; half/full circle	Decreases hyperarousal and feelings of anxiety, tension, fear
Child's Pose	From floor; from chair; arms straight out; arms behind; side-to-side	Grounding, centering, balancing; helps alleviate emotional overwhelm, feeling unsafe/unprotected
Tabletop	Spinal isolations (e.g., Cat pose; C-curve)	Grounding, balancing, centering; energizing and helps alleviate low energy
Tree Pose	Foot placement at ankle, calf, thigh; arm placement at side, on hips, reaching up	Balancing; body awareness in space (somatic sensory awareness); concentration/focus; Helps with alleviating feeling helpless and disempowered; dissociation
Chair Pose	Arm placement up, reaching out, at sides; twists	Energizing, confidence-building; inner strength and empowerment; release tension

Standing Forward Fold	Knees bent; arm placement at sides or holding elbows; from chair	Feeling anxious, rigid, holding on to emotions; helps release and let go; balancing; refreshing
Little Bridge	Hip placement variations; length of hold	Alleviates anxiety, stress, tension; inner strength and confidence building
Knee Hug	Seated, lying down, in chair; one at a time or both	Alleviates core symptoms of constipation, trapped emotions; self-soothing, protection
Boat Pose	Seated; foot placement on ground or in air; arm placement on legs or at sides	Feeling out of balance; centering, conflicted feelings; empowerment, inner strength, sensing body
Seated Forward Fold	Hand placement on floor, legs, shins, feet; straight and rounded spine	Alleviates anxiety, tension, holding on to emotions; balancing, self-protection, containment; helps with feelings of overwhelm
Straight Leg Side Stretch	Hand placement variations on floor, legs, shin, foot	Feeling disempowered, off-balance; helps release stored emotions, rigidity
Reclining Twist	One or both knees twisting, neck stretches	Alleviates tension, anxiety, emotional upset; body-awareness; addresses emotional numbing and dissociation
Final Resting Pose	Seated or lying down; eyes open or closed; arms at sides or over heart/stomach	Body awareness: release and let go; grounding, centering, balancing

The yoga instruction provided participants with safe, consistent, predictable and empowered prompts (e.g., choice to spend more time in a yoga posture, or return to a different posture) while eliminating certain exercises known to cause a triggering of PTSD symptoms (e.g., supine hip openers; not asking people to stay still; Emerson & Hopper, 2011). Participants were instructed to develop a personal "trigger reduction plan" if a retriggering occurred during a yoga session. The instructor provided suggestions such as having a weighted blanket, pillow, journal or tissues near reach, and to practice while facing the doorway and near a wall to lean against, if difficult sensations were to emerge. Participants were encouraged to discuss sensations, emotions and experiences felt during the yoga sessions on the weekly counselling calls and were prompted to develop positive self-coping strategies like staying in or choosing a specific posture that feels more neutral or effectively alleviates symptoms (e.g., child's pose when feelings of overwhelm arise). In terms of the environment, the yoga teacher recorded the

online yoga classes from the same environment each time without music, chanting, mudras, or other mysterious components (e.g., Chakra cleansing) that could cause dissociation, discomfort, and withdrawal (Emerson & Hopper, 2011). The teacher remained open to feedback from the participants and responded to reasonable requests such as offering alternative mindfulness practices. A significant focus on bodily control where participants were in full control of making the choice to modify a posture, stay in it, or move out of it was given since the nature of PTSD lies in control dynamics (Emerson & Hopper, 2011; van der Kolk et al., 2014). The trauma-informed approach of the online delivery eliminated the potential fear of being triggered through physical hands-on assists by the instructor with the intention to empower the individual to strengthen their internal locus of control regarding their own body (Emerson & Hopper, 2011; van der Kolk et al., 2014). Overall, the intervention program offered eight pre-recorded 20-minute online yoga sessions available throughout the week for participants to use for their home-based practice that were available for participants 24 hours/day to watch or listen to on computers, cell phones, or tablets at any time.

In addition to the weekly yoga videos, the doctoral student (MKC), in consultation with the clinical supervisor who has extensive training and experience as a clinical psychologist and mindfulness facilitator (PR), prepared a total of 56 pre-recorded guided mindfulness meditation audios based on mindfulness practices (e.g., breath awareness, body scan) and CBT principles (e.g., all-or-nothing thinking, cognitive distortions) that corresponded to the weekly module theme. Guided meditations were divided across the eight modules and ranged in length from 90-seconds to 20-minutes. As an added resource, a comprehensive breath technique manual, was created by the study coordinator (MKC) that outlined ten different established breath techniques (e.g., three-part breath, paused breath retention) emphasizing autonomic balance and emotion

regulation. Overall, there was over 12 hours of pre-recorded guided yoga and mindfulness content accessible to participants 24 hours/day in-between counselling sessions.

Weekly Phone-Based Therapist Support

To enhance program adherence and cognitive processing, participants met weekly for a 60-minute individual online CBT-based counselling session with the doctoral-level student undertaking the intervention (MKC). The meetings took place through secure, encrypted video-conference meetings (e.g., www.zoom.us) for the duration of the program to discuss symptoms, specific goals, weekly progress and personal barriers, and mindfulness practices for symptom reduction. Therapeutic coaching/counselling support has been demonstrated to lead to health-related behaviour modifications (e.g., physical activity, weight loss), and it appears to play an important role in enhancing participant self-awareness, accountability, and program adherence (Duncan et al., 2011; Pirbaglou et al., 2018; Spring et al., 2010, 2012, 2013). Participants also interacted via email such that email exchanges and/or video conferences occurred at weekly intervals, in accord with a standardized health coaching protocol adapted from previously successful RCTs in improving physical activity, weight loss, and program adherence (Duncan et al., 2011; Pirbaglou et al., 2018; Spring et al., 2010, 2012, 2013). Each session was client-centered and oriented to discussions of difficult cognitions, program adherence, and personal goal setting. The study intervenor (MKC) attended weekly clinical group CBT training and supervision, and participated in daily and/or weekly individual supervision sessions with the clinical psychologist overseeing the study (PR). The intervenor also participated in individual personal counselling with a licensed clinical psychologist external to the study to debrief personal emotions and challenges that arose from the clinical trial.

Program Prescription

In addition to the 60 minutes of weekly counselling sessions, participants were encouraged to engage with the online material and accumulate the following throughout the week: 1) 10 min of daily guided mindfulness practice in 5 min bouts from the online program on the majority of days each week for an approximate total of 60 minutes of guided meditation per week, 2) a minimum of 20 min of guided CBT-MY yoga from the intervention per week, and 3) 2-5 min of a daily breath technique practice from the breath manual. Participants were given full autonomy on how to use the online video and meditation content and were encouraged to complete and return to as many sessions as they felt comfortable with. Altogether, the participants were instructed to accumulate approximately 90 min of combined yoga and mindfulness practice each week for a total self-guided prescription of 720 min (12-hr) across the 8-week intervention.

Measurement and Instrumentation

Primary Psychometric Outcome Measures

DSM-5 PTSD Criterion A: Trauma Exposure Measure

Life Events Checklist for DSM-5 (LEC-5)

The presence of *DSM-5* Criterion A: Trauma Exposure was affirmed prior to measuring *DSM-5* PTSD symptoms (Weathers, Blake, et al., 2013). The Life Events Checklist for *DSM*-5 (LEC-5; Gray et al., 2004; Weathers, Blake, et al., 2013) was used to establish PTSD trauma exposure. The LEC-5 is a self-report measure that screens for a wide range of potentially traumatic events across a participant's lifetime. The LEC-5 questionnaire consists of 16 stressful and traumatic life events associated with PTSD (e.g., natural disaster, sexual assault).

Respondents were asked to indicate exposure to each event based on six possible exposure options: *directly happened to me; witnessed it; learned about it; part of my job; not sure;* and *does not apply* (Weathers, Blake, et al., 2013). The LEC-5 includes an additional item asking for "other" traumatic events not highlighted in the 16-item questionnaire (See Appendix D).

The LEC-5 was chosen because it contains subjective experiences of trauma exposure (e.g., psychological abuse) that are not included in the *DSM-5* Criterion A definition (e.g., CAPS-5). The LEC-5 does not yield a total composite score but is intended to gather information about the quantity and types of traumatic experiences a person has been exposed to across their lifespan. The psychometric properties of the LEC-5 have been previously validated and have demonstrated adequate temporal stability (weighted kappa = 0.61; retest correlation $r = .82$, $p < .001$), convergence validity with the CAPS-5 and significant correlations with traumatic exposures in college undergraduates (Elhai et al., 2005; Gray et al., 2004).

DSM-5 **PTSD Symptom Severity**

Clinician Administered Posttraumatic Stress Scale for DSM-5 (CAPS-5)

All psychometric instruments used are presented in Appendix D. PTSD symptom severity was assessed using the CAPS-5, often considered the "gold standard" in PTSD assessment (Weathers et al., 1999, 2001, 2018). The CAPS-5 is a 30-item structured in-person interview administered by a trained clinician that confirms a current (i.e., past month) or lifetime diagnosis of PTSD and assesses PTSD symptoms. The CAPS-5 was administered by the doctoral student who underwent training by the US Department of Veterans Affairs to administer the CAPS-5. The clinical psychologist overseeing this dissertation provided supervision and mentoring throughout the entire duration of the study. There are three versions of the CAPS-5 based on different time periods of recall including the *past week, past month*, and *worst month* (in the

subject's lifetime). For the purposes of this study, the CAPS-5 was used to evaluate PTSD diagnostic criteria within the *past month* to ensure participants receiving the intervention were adequately symptomatic. The CAPS-5 is a 30-item structured interview that aligns with the *DSM-5* PTSD diagnostic criteria and assesses the 20 *DSM-5* PTSD symptoms (American Psychiatric Association, 2013; Weathers et al., 2018). The questions target symptom presence, intensity, duration, subjective levels of distress, and the impact of the symptoms on functioning (e.g., social, occupational). Prior to the CAPS-5 being administered, the clinician asked the respondent to identify a primary or index traumatic event (e.g., most recent, most severe) to serve as the basis for symptom inquiry. Then, a succession of questions based on each *DSM-5* PTSD symptom criteria are asked verbatim.

CAPS-5 interview items are rated with a single severity/distress score and the assessor combines the information shared about the frequency/intensity of a symptom item into a single severity rating of distress based on a 5-point Likert scale: 0 = *absent/no symptom*; 1 = *mild/symptom minimal*; 2 = *moderate/symptom clearly present*; 3 = *severe/symptom pronounced*; 4 = *extreme/symptom is incapacitating*. For a clinically significant symptom to be deemed present, the respondent must describe a clinically significant problem that occurs at a minimum frequency of twice per month, or 'some of the time' (i.e. 20-30% of the time during a month) *plus* a minimum intensity threshold score of 2 = *moderate/clearly present* (Orsillo, 2002; Weathers et al., 2018). A total symptom severity score is calculated by summing severity scores for the 20 *DSM-5* PTSD symptoms and a separate cluster severity score is calculated by summing the individual item scores that correspond to a specific *DSM-5* subscale criterion:

- Criterion B: Intrusion Symptoms (symptom items 1-5)
- Criterion C: Avoidance Symptoms (symptom items 6-7)
- Criterion D: Negative Cognitions and Mood Symptoms (symptom items 8-14)
- Criterion E: Arousal and Reactivity Symptoms (symptom items 15-20)

- Dissociation Subtype: Depersonalization or Derealization

Due to resource limitations, assessor blinding was not undertaken and the study coordinator who completed the CAPS-5 interview was also the intervenor throughout the 8-week program. However, in an attempt to mitigate some bias, all CAPS-5 interview notes and scoring were independently cross-checked and assessed by a 2nd trained clinician, with no relation to the study. Discrepancies were resolved through discussion, and in consultation with the supervising clinical psychologist until consensus was achieved. The CAPS-5 PTSD diagnosis scoring criteria demonstrates strong interrater reliability and adequate test-retest reliability in military veteran participants (Weathers et al., 2018). CAPS-5 total severity score met a high internal consistency ($\alpha = .88$) with strong interrater reliability (ICC = .91) and good test-retest reliability (ICC = .78; Weathers et al., 2018).

PTSD Checklist for DSM-5 – Civilian Version (PCL-5)

The PCL-5 was used as an additional measure of PTSD symptom severity to provide further validation of the psychometric outcomes (Weathers, Litz et al., 2013). The PCL-5 is a standardized self-rated questionnaire consisting of 20 items that measure *DSM-5* PTSD symptoms within the last month. Participants indicate how much they have been bothered by a symptom item listed over the past month using a five-point Likert scale ranging from 0 = *not at all* to 4 = *extremely*. The PCL-C is easily scored by summing all of the items for a total symptom severity score, ranging between 0 to 80. The PCL-5 determines provisional PTSD symptoms are present if items are rated as a minimum of 2 = *moderately* or higher (Weathers, Litz et al., 2013). A cut-point score of 31-33 is the recommended minimum threshold of clinically meaningful PTSD diagnostic symptoms, however, validation studies along these lines are preliminary (Blevins et al., 2015). There are no empirically derived severity ranges for the PCL-5. The PCL-

C has been evaluated for reliability and validity in a nonclinical sample of 471 undergraduate students (Conybeare et al., 2012). The PCL-C demonstrated good internal consistency (Cronbach's alpha = .94) and retest reliability (r = .66) in this student sample. Convergent and discriminant validity were also established and deemed favorable in relation to alternative self-report measures of PTSD (Conybeare et al., 2012). Overall, the PCL-5 has demonstrated good internal consistency (α = .94) and good test-retest reliability (r = .82; Blevins et al., 2015).

Secondary Psychometric Outcome Measures

Comorbid conditions (e.g., symptoms of anxiety and depression) were obtained via self-report online questionnaire (See Appendix D) using Survey Monkey Inc. (San Mateo, California; www.surveymonkey.com), a 64-bit encrypted password-protected survey software. The following secondary outcome measures were obtained:

Beck Depression Inventory–II (BDI-II)

Depression symptoms were assessed using the Beck Depression Inventory-II (BDI-II; Beck et al., 1996), the most recent version of a 21-item self-report survey to assess depression symptom severity among respondents. The BDI-II evaluates symptoms and attitudes related to depression using a four-level weighted Likert response scale ranging from 0 = *not present* to 3= *severe* (Beck et al., 1996). The participants are instructed to respond to items pertaining to their mood within the past two weeks. Scoring for the BDI-II ranges from 0 to a maximum score of 63; empirically informed cut-off scores for levels of severity of depression include the following: 0-13 = *minimal depression,* 14-19 = *mild depression*, 20-28 = *moderate depression*, 29-63 = *severe depression* (Dozois et al., 1998). The BDI-II has been evaluated for validity and reliability in over 1400 undergraduate students and demonstrated good internal consistency estimates of reliability for total score (α = .90) and scores correlated significantly with measures of depressive

and anxious symptoms, supporting convergent validity (Storch et al., 2004). Utility of the BDI-II including criterion validity and test-retest reliability of the BDI-II has also been established in research studies (Beck, Steer, et al., 1988; Sprinkle et al., 2002; Wang & Gorenstein, 2013).

Beck Anxiety Inventory (BAI)

Anxiety symptoms were assessed using the Beck Anxiety Inventory (BAI; Beck, Epstein, et al., 1988; Steer & Beck, 1997). The BAI is a 21-item self-report inventory to assess symptoms of anxiety (e.g., "feeling hot," "difficulty breathing," "nervous") experienced during the last two weeks. Respondents are asked to rate how much each of the 21 symptoms bothered them in the past two weeks on a four-point Likert scale from 0 = *not at all* to 3 = *severely, it bothered me a lot*. Scoring for the BAI ranges from a minimum of 0 to a maximum of 63 based on summing the scores for all items. The following empirically supported cut-off scores are frequently used on the interpretation of anxiety severity: 0-9 = *normal/no anxiety*, 10-18 = *mild to moderate anxiety*, 19-29 = *moderate to severe anxiety*, 30-63 = *severe anxiety* (Steer & Beck, 1997). The BAI has been widely used in clinical (Fydrich et al., 1992) and non-clinical (Creamer et al., 1995) populations and demonstrated strong test-retest reliability over one week (r = .75) and internal consistency (α = .94). In addition, content, construct and convergent validity has been established for the BAI (Beck, Epstein, et al., 1988; Creamer et al., 1995; Fydrich et al., 1992; Steer & Beck, 1997).

Pain Catastrophizing Scale (PCS)

Pain catastrophizing was measured using the Pain Catastrophizing Scale (PCS; Sullivan, 1995). The PCS is a valid and reliable measure, that captures the catastrophizing of pain via pain-related thoughts, perceived helplessness, rumination, and exaggerated attentional focus on

the threat of pain stimuli (Sullivan, 1995). The PCS has 13 questions measured on a 5-point Likert scale (0= *not at all*, 4 = *all the time*) and consists of three subscales: rumination (α = .87), magnification (α = .66), and helplessness in relation to pain (α = .78; Sullivan, 1995). Total PCS score is computed by summing the responses and scores range from 0-52. Higher scores indicate higher levels of pain-related anxiety and a total PCS score of 30 represents clinically relevant pain-related anxiety (Sullivan, 1995).

Brief Pain Inventory (BPI)

Pain severity and interference were assessed using the Brief Pain Inventory (BPI; Cleeland, 1989; Cleeland & Ryan, 1991). The BPI-SF is a 16-item, self-report questionnaire that uses an 11-point numeric rating scale (NRS) of 0-10 with end points labeled 0 = *no pain* and 10 = *pain as bad as you can imagine* measuring the severity of the "worst" and "least" pain the past 24 hours, as well as the participant's "average" and present pain ("right now"). Another 0-10 NRS (with end points labeled 0 = *does not interfere* and 10 = *completely interferes*) measures the extent to which the pain interferes with seven daily activities, including general activity, mood, walking ability, work, relations with other people, sleep, and life enjoyment. The BPI has been used extensively in a variety of pain conditions and has excellent psychometric properties, including validity and reliability in patients with chronic non-malignant pain (Tan et al., 2004).

Five Facet Mindfulness Questionnaire (FFMQ)

Daily mindfulness experiences were measured using the 39-item Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006). The FFMQ has been established as a valid and reliable measure of mindfulness in undergraduate students and is commonly used to assess changes in mindfulness tendencies (e.g., nonjudging of inner experience) before and after a mindfulness-

based intervention (Baer et al., 2006, 2008). The FFMQ measures five mindfulness-based subscales: non-reactivity, observing, describing, nonjudgement, and acting with awareness. Participants were instructed to respond to each item by selecting the response that reflects what is "most generally true" of their experience. Item scores range on a five-level Likert scale of 1 = *never or rarely* true to 5 = *very often or always true.* The FFMQ is scored by summing all item responses and total scores range from 0 to 195, with higher scores indicating greater levels of mindfulness. The FFMQ also produces subscale scores for the five factors. The subscales have demonstrated good construct validity and internal consistency with alpha values ranging from α = .75 to .91 (Baer et al., 2008; de Bruin et al., 2012; Gu et al., 2016).

Psychophysiology Outcome Measurement and Instrumentation

International Affective Picture System

For the stress phase of the 25-minute computer protocol, a series of 60 negative emotional images from the International Affective Picture System (IAPS; Lang et al., 1997) were selected and each was presented for 10-seconds in duration to elicit a sympathetic nervous system response in both pupillary response and HRV. The IAPS provides normative ratings of affect for a large set of images based on the Self-Assessment Manikin (SAM) 9-point rating scale (Bradley & Lang, 1994) . A score of 9 represents a high rating (i.e., high pleasure, high arousal), a score of 5 indicates a neutral rating, and a rating of 1 represents a low pleasure, low arousal rating (Bradley & Lang, 1994). To ensure ethical considerations of PTSD, images that met the lowest pleasure ratings (< 2.0) or highest arousal ratings (> 6.5) were not included. All images were carefully screened and approved by the supervising clinical psychologist overseeing the trial (See Appendix E). Overall, the 60-images had a moderately low pleasure rating (*M* =

3.05, *SD* = 1.63, Range = 1.79-4.30) and a moderately high arousal rating (*M* = 5.51, *SD* = 2.13, Range = 3.93-6.93; Lang et al., 1997).

Pupillometry

Changes in pupil dilation were captured as a marker of autonomic function using the Tobii Pro T60XL 2.0 eye tracking glasses (Tobii Pro, 2018). The Tobii Pro T60XL 2.0 glasses provide pupil size change information for each eye and combine this data with Tobii Pro Studio Software to calculate relative change in pupil size and to provide an overall percentage-change in pupil dilation. The Tobii Pro T60XL 2.0 eye tracking glasses provide data about the distance between the eye and the sensor, and specialized firmware calculates the pupil size by measuring the diameter of the pupil on the image and multiplying it with a scaling factor. Resting pupil diameters for both the left and right pupil were calculated as the weighted mean pupil size during the 200 ms directly preceding the onset of a neutral fixation cross that randomly moved around the computer screen in a 9-point grid every 10 s (30 images) during the 5-minute baseline phase. Peak pupil dilation (PPD) was calculated by taking the maximum pupil response within the first 500 ms after an image stimulus onset and then averaging these per image responses across: 30 fixation crosses during the baseline rest phase, 60 images during the 10 min emotional stress phase, and 60 fixation crosses during the 10 min guided meditation phase (Burkhouse et al., 2015; Snowden et al., 2016). The first 300-500 ms of measurement is recommended for autonomic pupillary response to stimuli where no saccades could be initiated (e.g., ballistic fast movements of the eyes, image avoidance; Gilchrist, 2011; Snowden et al., 2016). Data were cleaned using recommendations by Siegle et al. (2008). Changes in pupil dilation were recorded every 20 ms (60 Hz) and captured for 10 s following the onset of an image stimulus using Tobii Pro Software (www.tobiipro.com). Trials that comprised over 50% blinks were removed from

data and resulted in one participant exclusion (5.5%). Data were inspected for noise and outlier samples in Python programming software (www.python.org) prior to analysis. Artifacts were identified based on guidelines from Kret & Sjak-Shie (2019) and were removed. After eye-blinks and artifacts were removed, a linear interpolation function was applied to the data to accommodate for missing values. To increase the temporal resolution and smoothness of the data, the data points were resampled with interpolation to a high sampling rate (1000 Hz). The resulting time-series signal was then smoothed using a zero-phase low-pass filter, with a cut-off frequency of 4 Hz (Jackson & Sirois, 2009). The final step was to calculate the relative peak pupil diameter (% change) from the calculated resting pupil size based on recommendations by Tobii Pro Studio software (Tobii Pro, 2018). The Tobii Pro 2.0 glasses have optical sensors that calculate pupillometry measure based on eye model algorithms. Since the glasses do not report an actual ground-truth, physical pupil diameter, it is advised to use relative change measures such as percentage change in dilation as an indicator of physiological arousal (Tobii Pro, 2020).

Heart Rate Variability

A secondary objective measure of autonomic response involved changes in HRV from pre- to post-intervention period during the 25 min protocol, consisting of rest, stress, and meditation phases. HRV is a non-invasive procedure that uses electrocardiogram (ECG) data to assess cardiac autonomic nervous system activity (e.g., autonomic regulation). Recordings of ECG data were taken using ADInstruments (ADI) PowerLab 4-channel data acquisition system. LabChart Pro software by ADI is integrated with the ECG unit and was used to obtain computer digitized ECG signal from the PowerLab unit at a sampling rate of 1000 Hz. ECG data was collected and prepared in accordance with the standards set by the Task Force of the European Society of Cardiology (TFESC) the North American Society of Pacing Electrophysiology

(TFESC, 1996) including analysis of 5-minute epochs. LabChart Pro uses automated ECG interpretation which indicates ectopic and normal beats. Data were visually inspected to ensure each R-R heartbeat interval had clear PQRST formation. The "beat classifier view" feature in LabChart 8 Pro was used to inspect ectopic beats. The data was also inspected to confirm the absence of artifacts and cardiac arrhythmias. High frequency HRV (0.15-0.40Hz) is conventionally an estimate of short-term recordings of vagal modulation and parasympathetic nervous system activity in HRV (TFESC, 1996), and is the primary outcome variable measured in this analysis. Under controlled conditions, the natural logarithm of HF HRV is best used to estimate vagal tone. This HRV metric is preferred to other metrics due to having better statistical properties and strong correlation with HF HRV (TFESC, 1996). RMSSD, a time-domain measure of HRV, is another outcome measure that was captured, but not used as the primary outcome measure. RMSSD and HF HRV are consistent when respiration is controlled (Grossman & Taylor, 2007). Respiration was collected using a respiratory belt and controlled for in analyses. Average cyclical rate was calculated using LabChart Pro.

Program Adherence and Satisfaction

Given the novelty of the online 8-week intervention, it was important to understand the person-level factors associated with program adherence and engagement. Protocol completers were identified as those who completed both baseline and post-intervention measures. Attendance rate and duration of counselling calls were tracked by the intervening doctoral student. Self-reported 7-day recall of time spent in self-directed practice was tracked weekly at the start of each counselling call. As an added strategy, Google Analytics software was linked to the intervention website to monitor online website analytics of visitors during the recruitment period from October 25, 2018 to February 15, 2020. Patterns of usage and duration among return

uses and bounce rate were captured as performance indicators. Bounce rate is an indicator that measures the percentage of people who land on a website and leave without engaging in the site. It is calculated as the number of single-page visits (e.g., homepage only) divided by all sessions (e.g., multiple pages) and expressed as a percentage of users who viewed only a single page and triggered only a single request to the analytics server (Google Analytics, 2020). A lower bounce rate indicates that users are spending time engaging with the website content (e.g., viewing multiple pages). According to Google Analytics, a bounce rate of >70% indicates less engagement and time spent on the website and a bounce rate of <40% is an indicator of strong website engagement (Google Analytics, 2020).

A CBT-MY Satisfaction Questionnaire was created to capture anecdotal feedback about program usefulness and satisfaction of the intervention. The self-report questionnaire was administered at post-intervention and was a study-generated satisfaction survey. Participants were first asked to rate six unique components (e.g., weekly phone-based counselling, yoga videos, meditation audios) of the intervention from 1 = *most valuable/helpful* to 6 = *least valuable/helpful*. In terms of program satisfaction, a series of 10 self-reported Likert-scale questions pertaining to level of satisfaction of various program components were scored as, 0 = *strongly disagree* to 4 = *strongly agree*, and used to assess overall satisfaction with the CBT-MY program (See Appendix D).

Statistical Analysis Plan

Quantitative statistical analysis of the survey data was conducted using the IBM Statistical Package for the Social Sciences (SPSS) version 23.0 for Windows. All data were collected, coded, cross-checked, and cleaned by the primary investigator prior to statistical analysis. Preliminary analysis of demographic variables and baseline descriptive statistics of

psychometric data were calculated for each participant and summarized as group data. Numeric variables (e.g., age) are presented as means and standard deviations; categorical data (e.g., yes/no) are presented as frequencies and percentages. Initial analyses were conducted to assess missing data, identify outliers and examine the data for assumptions of normality. The normality of distribution among outcome variables was assessed by examining the skewness and kurtosis statistics. Skewness scores with a *z*-score value greater than 3.29 were converted to a score of 3.00 to fall within an acceptable range (Field, 2005). Among the psychometric measures, no psychometric scale (e.g., PCL-5, BDI-II) had skewness scores greater than 1.96 and resulted in acceptable ranges of normality. Hypothesis testing was conducted using the specific analysis procedures below.

Pre-Post Change in Psychometric Outcomes

> ***H1:*** *Clinically significant reductions in CAPS-5 scores, defined as a minimum reduction of 10 points* (Stefanovics et al., 2018)*, are expected at post-intervention.*
>
> ***H2:*** *Clinically significant reductions, defined as a reduction of 17.5%, in scores* (Button et al., 2015)*, on the PCL-5, BDI-II, BAI, PCS and BPI are expected at post-intervention.*
>
> ***H3:*** *Participants who complete the intervention will report clinically significant (p <.05) increases in the Five Facet Mindfulness Questionnaire (FFMQ) scores.*

Prior to conducting the pre-post analysis, the assumption of normality was examined and considered satisfied as the skew and kurtosis values of all variables were less than the maximum recommended values allowed for a *t*-test (i.e., skew ≤ 2.0, kurtosis ≤ 9.0; Posten, 1984). To assess **H1, H2** and **H3** paired samples *t*-tests (comparing baseline (T1) and post-intervention (T2)) were conducted to assess within-person change in psychometric outcomes after the 8-week CBT-MY treatment. Effect sizes (Cohen's *d*) were calculated for within-person changes, and

were interpreted as, d = 0.23, 0.50, 0.80, indicating small, medium and large effect sizes (Cohen, 1992; Rosenthal, 1994). The MCID in psychometric scores were calculated according to pre-determined criteria (e.g., ≥ 10-point reduction in PTSD total symptom severity score on CAPS-5 or PCL-5; Stefanovics et al., 2018).

Both intention-to-treat (ITT) analysis and per-protocol (PP) analysis were calculated. Missing data due to withdrawal or loss to follow-up, were handled using last observation carried forward (LOCF). ITT analysis is the preferred approach to analyzing intervention data as per CONSORT guidelines and gives an unbiased estimate of the treatment effect (Schulz et al., 2010). ITT provides full reporting of any deviations of the intervention and includes every participant who enrolled in the intervention and completed baseline measures, regardless of whether they completed the intervention. PP analysis was also reported to ascertain the intervention effect among participants that completed the entire protocol.

Objective Psychophysiology Outcome Measures

> ***H4:*** *Significant change in HRV and pupillometry across the 25-minute lab protocol of rest, stress, and meditation are expected. Compared to rest, HRV is expected to significantly decrease during the stress phase and increase during meditation. Peak pupil dilation (PPD) is expected to significantly increase during stress and decrease during meditation.*
>
> ***H5****: Significant overall reductions in PPD and increases in HRV are expected at post-intervention.*

Prior to analyses, raw HF HRV data and peak pupil dilation (PPD) were examined for normality. HF HRV was natural log transformed to adjust for positively skewed data (Shapiro-Wilk test, p <.001). To evaluate **H4** and **H5,** linear mixed effects modelling (LME) procedures using

multilevel regression was selected as the appropriate statistical approach to include all cases in unbalanced data (Gelman & Hill, 2006). A 2-Level LME was conducted with the natural log of HF HRV or PPD set as the outcome variable with predictors Protocol Condition, Time, and Treatment Group. The LME had two levels: 1) level one included the individual measurements on a given participant at a given time (e.g., only baseline for some participants), and 2) level two was the participant. The fixed factors were coded as the following: Treatment group (0 = PTSD participants who received intervention vs. 1= Non-PTSD participant), Time (0 = baseline, 1 = 8-week follow-up) and Protocol Condition (e.g., 0 = baseline rest 0-5 mins, 1 = emotional image stress task (EST) 0-5 mins, 2 = EST 5-10 mins, 3 = guided meditation (GM) 0-5 mins, 4 = GM 5-10 mins). For the within-person repeated measures, PTSD participants had two repeated measures: Time (baseline vs. 8-week follow-up) and protocol condition (BL, EST 0-5 min, EST 5-10 min, GM 0-5 min, GM 5-10 min). The convenience non-PTSD participants had one repeated measure: Protocol condition (BL, EST 0-5 min, EST 5-10 min, GM 0-5 min, GM 5-10 min). Non-PTSD participants were coded for Time as *0 = baseline* and for Treatment Group *0 = did not receive intervention*. The model included a random intercept to account for random effects. Significant main effects of pre-post and protocol conditions were evaluated with pairwise comparisons using a Bonferroni Type 1 error rate correction. Post-hoc analyses using independent (PTSD vs. Non-PTSD) and paired samples *t*-tests (pre-post intervention measures for PTSD participants) were conducted to ascertain where significant differences emerged. Psychophysiology outcome measures were conducted using per-protocol (PP) analysis to determine the objective treatment effect on psychophysiology of participants who complied to the protocol.

H6: *PTSD participants are expected to show significantly lower HRV and increased PPD at baseline measures only compared to cross-sectional data of a convenience sample of non-PTSD participants. Post-intervention outcome measures will be non-significant.*

The study did not have a control group that completed pre-post measurements. To make preliminary comparisons, a convenience sample of non-PTSD participants was used as a comparison group to evaluate **H6** psychophysiology outcome measures. The non-PTSD sample only completed the 25-minute protocol at one time point. Based on recommendations by Koenig et al. (2016), independent samples *t*-test were calculated to verify if significant differences in average cyclical breath rate occurred between PTSD and non-PTSD participants (Koenig et al., 2016). Respiration was then entered as a covariate in subsequent analyses to account for differences. LME procedures using multilevel regression was selected as the appropriate statistical approach to include the non-PTSD data into the model with the PTSD participant data (Gelman & Hill, 2006). An LME approach with all data entered into one model allows the analysis to be more parsimonious and more accurate (Gelman & Hill, 2006). The exact same LME procedures for **H4** and **H5** were followed for evaluating **H6.**

Exploratory Analysis

EQ1: *Do certain baseline mental health profiles (e.g., PTSD + severe depression) explain the variance in baseline PTSD symptom severity?*

Given the limited research examining young adults with PTSD in Canada, exploratory bivariate correlations of baseline demographics and psychometric variables with CAPS-5 PTSD symptom severity score were calculated to determine significant correlates of PTSD symptom severity at baseline, prior to any intervention. Correlations that were significant at the $p < .05$ level were included as predictors multiple linear regression analyses using forward selection to examine

whether the variance in baseline and/or post-intervention CAPS-5 PTSD symptom severity could be explained by significantly correlated psychometric and demographic outcomes. Forward selection starts with a null model with no predictors and is an acceptable method for exploratory analysis. Predictors are added one at a time beginning with the predictor with the highest correlation or greater theoretical importance (Field, 2013).

EQ2: *Do certain mental health profiles (e.g., PTSD + severe depression) moderate psychophysiology measures before and after an 8-week online CBT-MY intervention?*

Given the significant overlap of comorbid depression with PTSD and the potential impact it may have on psychophysiology, exploratory analyses were conducted to examine whether severity of comorbid depression was linked to changes in pre-post psychophysiology measures. Exploratory covariate analysis, with baseline depression score (BDI-II) entered as a covariate, was conducted using LME modelling to assess whether the main effects of protocol condition and pre-post change in HRV and PPD remained stable after controlling for depression. Baseline depression score was chosen because: 1) depression is more of a stable symptom presentation than anxiety, and 2) post-intervention BDI-II may not be as accurate due to the potential for social desirability bias.

Chapter 4: Results

Chapter 4 summarizes the quantitative statistical results of the clinical trial and is divided into four sections based on the research questions and hypotheses: 1) baseline descriptive statistics and analyses of baseline psychometric outcome variables, 2) pre-post statistical analyses of the psychometric outcomes following the 8-week online intervention, 3) statistical analyses of the psychophysiology outcomes and comparisons with non-PTSD participants and 4) program adherence, satisfaction and engagement results.

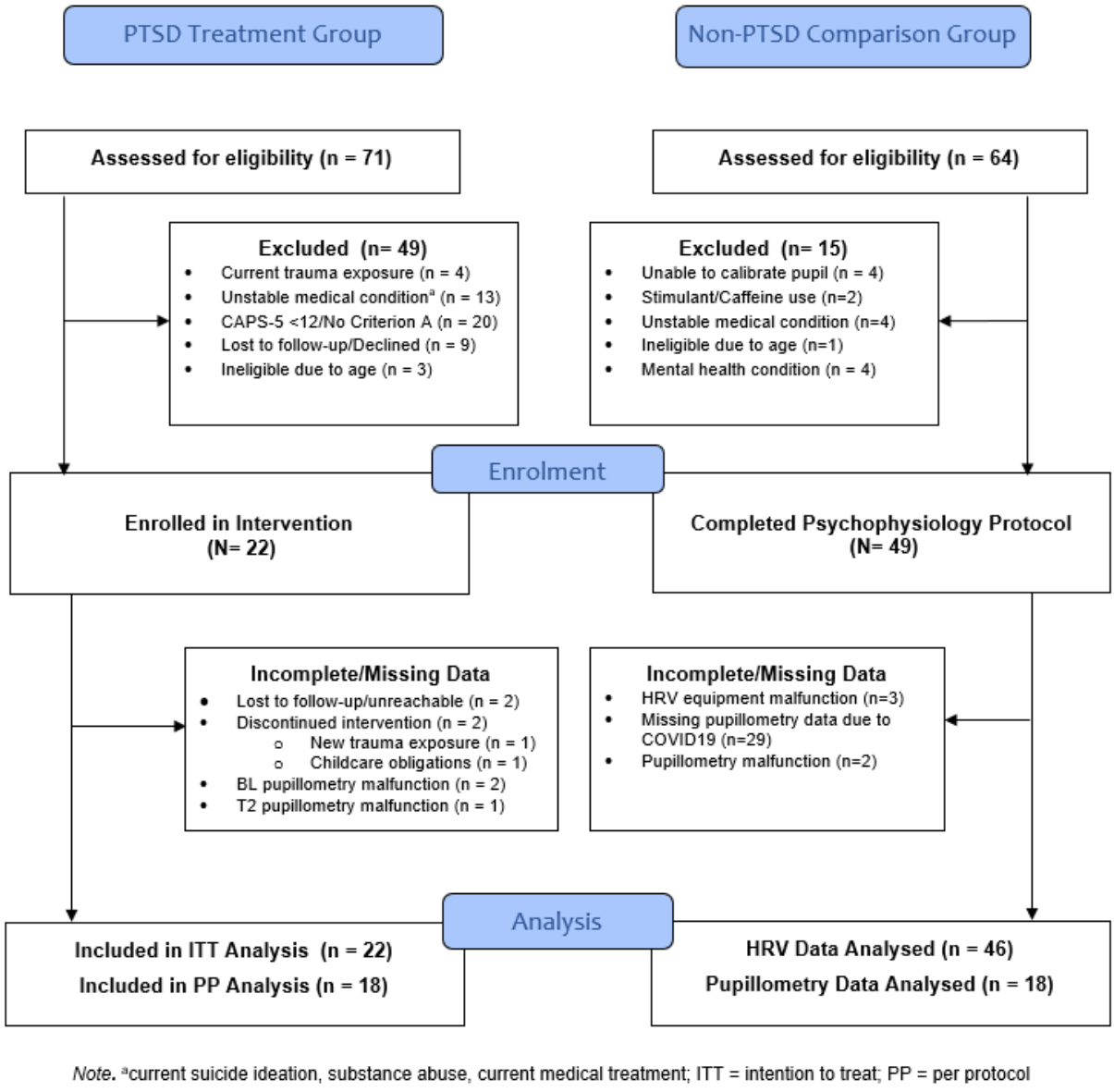
Figure 4 illustrates the CONSORT flow diagram of participant recruitment and flow over the course of study. Overall, 71 adults, ages 18-35 years, were screened for eligibility from October 2018 to December 2019. A total of 49 adults (69.0%) were deemed ineligible to participants based on the following exclusion criteria: current trauma exposures (n = 4, 8.2%), high suicide risk or unstable medical condition (n = 13, 26.5%), a CAPS-5 score < 12 or no clear trauma exposure (Criterion A; n = 20, 40.8%), unable to be contacted (n = 9, 18.4%), or ineligible age (n = 3, 6.1%). Based on these criteria, 22 adults (44.9%) met the inclusion criteria and provided informed written consent to participate in the intervention. Four participants had missing or incomplete data; two participants (9.1%) withdrew from the study (week 2 = 1, week 7 = 1) with reasons, and an additional two participants were lost to follow-up (week 2 n = 1; week 8 n = 1; 9.1%).

Given the exploratory nature of the psychophysiology measurements, a convenience cohort of adults, ages 18-25, with no prior history of PTSD or mental health diagnosis were recruited from an undergraduate research pool as a comparison cohort. The non-PTSD sample completed the 25-minute psychophysiology protocol at a single time-point to enable comparisons of physiological differences (i.e., HRV and pupillometry) with PTSD intervention

participants. This study compares HRV data of PTSD participants with 46 non-PTSD participants and pilot pupillometry data findings for 18 non-PTSD participants.

Figure 4

CONSORT Flow Diagram of Participant Enrollment and Analysis



Note. [a]current suicide ideation, substance abuse, current medical treatment; ITT = intention to treat; PP = per protocol

Part 1: Baseline Demographics and Characteristics of the PTSD Participants (*n* = 22)

Basic demographics and clinical characteristics of PTSD intervention participants are presented in Table 6. PTSD Participants were 26.4 years old (*SD* = 4.45), and the majority were female (*n* = 18, 81.8%). Ethnically, 59.1% were Caucasian, followed by Middle Eastern (13.6%) or mixed-race (13.6%). Ten participants were landed immigrants (45.5%) and resided in their country of origin for an average of 12.8 years (*SD* = 11.1) prior to immigration to Canada. Half the participants (*n* = 11) reported a pre-existing health condition with obesity/overweight as the most prevalent (*n* = 4, 16.7%). The majority of participants (*n* = 18, 81.8%) reported a clinical mental health diagnosis confirmed by a clinical mental health professional. The mean number of concurrent clinical diagnoses was 2.27 (*SD* = 1.75). Eleven participants (50%) were currently taking prescription medication for a mental health condition. Of those taking medication for a mental health condition, the mean number of prescriptions was 1.41 (*SD* = 2.02). The majority of the participants indicated they did not have a consistent mindfulness practice of at least 10 minutes/day (*n* = 16, 72.7%).

Table 6

Demographic Characteristics of PTSD Intervention Participants (N = 22)

Variables	Value
Age (years) (*M* ± *SD*)	26.4 (4.45)
Gender (*n, %*)	
Female	18, 81.8%
Male	3, 13.6%
Non-Binary	1, 4.5%
Ethnicity (*n, %*)	
Caucasian (North American, European)	13, 59.1%
Black (African American, Caribbean)	1, 4.5%
Middle Eastern (Persian, Arab)	3, 13.6%
Asian (Chinese)	1, 4.5%
South Asian (Pakistan, Indian)	1, 4.5%
Mixed-Race	3, 13.6%
Immigration Status (*n, %*)	
Landed Immigrant	10, 45.5%
Canadian Citizen	12, 54.5%

Education Status (*n*, %)	
Undergraduate Degree In-Progress (BA, BSc)	16, 72.7%
2nd Degree In-Progress (MA, PhD, 2nd Bachelor's Degree)	6, 27.3%
Marital Status (*n*, %)	
Single	12, 54.5%
Dating	6, 27.3%
Common-Law/Married	4, 17.2%
Employment Status (*n*, %)	
Unemployed	5, 22.7%
Part-Time (0-35 hrs/week)	15, 68.2%
Full-Time (35+ hrs/week)	2, 9.1%
Pre-Existing Physical Health Condition (*n*, %)	
None	11, 50.0%
Obesity/Overweight	4, 16.7%
Fibromyalgia/Chronic Fatigue Syndrome	2, 11.1%
Auto-Immune Disorder	2, 11.1%
Other (i.e., Tinnitus, IBS, PCOS)	5, 27.8%
Pre-Diabetes	1, 4.5%
≥ 2 Conditions	4, 22.2%
Mental Health Diagnosis (*n*, %)	
Clinical diagnosis	18, 81.8%
≥ 2 diagnoses	14, 63.6%
Total Diagnoses (*M* ± *SD*)	2.27 ± 1.75
Prescription Medications for Mental Health (*n*, %)	
None	11, 50.0%
One Medical Prescription	6, 27.3%
≥ Two Medical Prescriptions	5, 22.7%
Total Medications (*M* ± *SD*)	1.41 ± 2.02
Mindfulness Practice (Mins/Day)	
0 min/day	16, 72.7%
< 10 min/day	6, 27.3%
>10 min/day	0, 0.0%

Note. IBS = irritable bowel syndrome; MDD = major depressive disorder; PCOS = polycystic ovarian syndrome; PTSD = posttraumatic stress disorder

Baseline Descriptive Data of Clinical Mental Health and Trauma Exposure Variables

Descriptive data of trauma exposure and clinical mental health variables of PTSD participants are summarized in Table 7. Clinical Anxiety (*n* = 14, 63.6%), depression (*n* = 13, 59.1%), and PTSD (*n* = 12, 54.5%) were reported as the most common diagnoses. All but two participants indicated they had previously engaged in talk therapy with a therapist (*n* = 20, 90.9%) as the most common mental health treatment. This was followed by pharmacotherapy (*n* = 11, 50.0%), EMDR (*n* = 4, 18.2%), alternative or complementary approaches (*n* = 4, 18.2%),

and hospitalization in a mental health unit (*n* = 3, 13.6%). At the time of enrollment, participants reported an average of 3.70 years (*SD* = 2.96) since the most recent trauma exposure.

In terms of trauma exposure, participants reported a mean total of 11.50 (*SD* = 5.92) trauma exposures across their entire lifespan with most exposures experienced directly (*M* = 5.14, *SD* = 1.86). The majority of participants (*n* = 19, 86.4%) reported physical assault as the most common trauma exposure. Nineteen (86.4%) disclosed experiencing direct childhood trauma exposure (ages of 0-17). Of these, an equal number of participants (*n* = 9, 47.4%) endured physical abuse during childhood or sexual assault. The average age of the first memory of trauma was reported as 6.66 years (*SD* = 4.40) with an average duration of repeated childhood trauma exposure of 9.97 years (*SD* = 4.62). The majority of childhood abuse was reported to have been perpetrated by a parent (*n* = 14, 73.7%), followed by multiple family members (*n* = 6, 27.3%), or a single family member (*n* = 4, 21.1%; see table 7).

Table 7

Self-Reported Mental Health and Trauma Exposure Variables (N = 22)

Mental Health and Trauma Exposure Variables	**Value**
***DSM-5* Clinical Mental Health Diagnosis (*n, %*)**	
PTSD	12, 54.5%
Depression	13, 59.1%
Anxiety	14, 63.6%
Borderline Personality Disorder	3, 13.6%
Addiction/Self-Harm	3, 13.6%
Multiple Diagnoses (≥ 2 diagnoses)	14, 63.6%
Other (i.e., attachment disorder)	1, 4.5%
Trauma Exposure (LEC-5; *M* ± *SD*)	
"Happened to me" (directly)	5.14 ± 1.86
"Witnessed it"	2.27 ± 1.96
"Learned about it"	3.55 ± 3.61
"Part of job"	.55 ± 2.35
Total trauma exposures	11.50 ± 5.92
Time Since Last Trauma Exposure (Years) (*M* ± *SD*)	3.50 ± 2.89

Direct Trauma Exposure Category (*n*, %)	
Physical Assault	19, 86.4%
Sexual Assault (e.g., rape, attempted rape)	17, 77.3%
Unwanted Sexual Experience (e.g., groping, sexual harassment)	17, 77.3%
Transportation Accident	10, 45.5%
Repeated trauma exposure*	20, 90.9%
Other (e.g., psychological abuse)	18, 81.8%
Childhood Trauma Exposure	
Happened to me (*n*, %)	19, 86.4%
Age of First Memory (*M* ± *SD*)	6.66 ± 4.40
Duration of Childhood Trauma (Years) (*M* ± *SD*)	9.97 ± 4.62
Childhood Abuser (*n*, %)	
Parent (*n*,%)	14, 73.7%
Family Member (*n*, %)	4, 21.1%
Multiple Family Members (*n, %*)	6, 27.3%
Friend/Acquaintance (*n*, %)	2, 10.5%
Stranger (*n*, %)	1, 5.3%
Type of Childhood Trauma	
Physical Abuse Only (*n, %)*	9, 47.4 %
Sexual Assault (*n, %*)	9, 47.4%
Verbal Emotional/Psychological Abuse (*n*, %)	16, 84.2%
Past Mental Health Treatment (*n, %*)	
Pharmacotherapy	11, 50.0%
Talk Therapy	20, 90.9%
EMDR	4, 18.2%
Hospitalization	3, 13.6%
Alternative/Complementary Medicine	4, 18.2%
Family History of Mental Health (*n*, %)	
Yes	15, 68.2%
No	7, 31.8%

Note. *Repeated by the same perpetrator/abuser or repeated type of exposure; EMDR = eye-movement desensitization and reprocessing, LEC-5 = Life Events Checklist for *DSM*-5; PTSD = posttraumatic stress disorder

Baseline Psychometric Survey Outcomes

Table 8 highlights the baseline psychometric survey outcomes for PTSD and co-morbidities of depression and anxiety among PTSD participants. PTSD symptom severity, symptom diagnosis and clinical diagnostic criteria were assessed using the Clinician Administered PTSD Scale for *DSM-5* (CAPS-5; Weathers et al., 2018). To assess PTSD diagnostic criteria, a symptom was considered present only if the corresponding item severity score was rated 2 = *Moderate / threshold* or higher (Weathers et al., 2018). Based on these criteria, participants met criteria for 15.33 (*SD* = 2.10) of the 20 symptoms. Total CAPS-5

symptom severity score (*M* = 47.09, *SD* = 9.09) met and exceeded the threshold criteria for PTSD symptom severity. Twenty (90.9%) participants met full clinical criteria for a PTSD diagnosis as identified by CAPS-5 and 100% of participants met the threshold PTSD score (≥ 31) on PCL-5 (*M* = 48.14, *SD* = 11.94) indicating the person may benefit from evidence-based treatment for PTSD. The CAPS-5 and PCL-5 were significantly associated (r = .63, p = .002). Therefore, two participants who did not meet the clinical criteria for PTSD on the CAPS-5, but did on the PCL-5, and reported severe symptom severity in several CAPS-5 criterion subscales with a history of repeated trauma exposure were included in the study. Twenty-one (95.5%) participants were found to have dissociative symptoms at baseline. Depression symptoms were assessed using the Beck Depression Inventory-II (BDI-II) and indicated "moderate" depression at baseline (*M* = 28.14, *SD* = 13.70). Symptoms of anxiety were assessed using the Beck Anxiety Index (BAI) and revealed participants had "severe" anxiety at baseline (*M* = 29.68, *SD* = 9.54). Additional analysis of potential significant differences in mental health outcomes of participants who withdrew from the clinical trial were conducted and revealed that those who withdrew (*n* =4) had significantly higher CAPS-5 Criterion D – Negative Cognition & Mood Symptoms (*M* = 21.50, *SD* = 2.65, $t_{7.55}$ = -2.95, p = .02) and overall PCL-5 PTSD symptom severity score (*M* = 59.75, *SD* = 6.90, $t_{7.24}$ = -3.25, p = .01) compared to those that completed the intervention.

Table 8

Baseline Descriptive Statistics of Psychometric Outcomes (N = 22)

Mental Health Survey Subscale	**Outcome Measure**		**Scoring Interpretation**
PTSD (CAPS-5)	***M***	***SD***	
Criterion B – Intrusion (/20)	12.23	2.86	Meets Threshold PTSD Criteria
Criterion C - Avoidance (/8)	5.18	1.89	Meets Threshold PTSD Criteria
Criterion D - Cognition/Mood (/28)	17.41	4.62	Meets Threshold PTSD Criteria
Criterion E - Arousal/Reactivity (/24)	12.27	4.32	Meets Threshold PTSD Criteria
TOTAL CAPS-5 Symptom Severity (/80)	47.09	9.09	Meets PTSD Diagnostic Criteria
TOTAL CAPS-5 Symptoms (/20)	15.33	2.10	Meets PTSD Diagnostic Criteria

PTSD Diagnosis (n, %)	20	90.9%	
w/ Dissociation (n, %)	21	95.5%	
PTSD (PCL-5)			
Total PCL-5 Symptom Severity (/80)	48.14	11.94	Score ≥ 31 = PTSD threshold
Depression (BDI-II)			
Total BDI-II Score (/63)	28.14	13.70	Score 20-28 = "Moderate" Depression
Anxiety (BAI)			
Total BAI Score (/63)	29.68	9.54	Score 26-63 = "Severe" Anxiety

Note. BAI = Beck Anxiety Index, BDI-II = Beck Depression Inventory-II, CAPS-5 = Clinician-Administered PTSD Scale for *DSM-5*; PCL-5 = PTSD Checklist for *DSM-5* civilian version; PCS = Pain Catastrophizing Scale

Baseline Pain Measures

Assessment of pain was introduced 6-months after initial recruitment due to anecdotal observation (see Table 9). Five participants had already completed the intervention and were no longer eligible to complete the pain measures. Of the remaining 17 participants, 13 (76.5%) reported current pain and completed the PCS and BPI. Table 9 highlights the descriptive statistics for pain outcome measures. Results of PCS were in the 50th percentile (*M* = 20.00, *SD* = 13.73) of pain. The Brief Pain Inventory (BPI) assesses current pain the day of completing the assessment. Of the 13 participants who completed pain measures, a total of nine (69.2%) participants completed the BPI and indicated they lived with current pain that day; four participants reported no current pain that day and were excluded from the analysis. Among the nine participants who experienced current pain, the worst, average and current pain severity had mean (*SD*) values of 5.11(*2.03*), 4.11(*1.69*), and 3.33(*1.50*), respectively. Overall, the average BPI Pain Severity Score was *M* = 4.10 (*SD* = 1.01). With respect to BPI Pain Interference items, pain interfered most with Mood (*M* = 6.22, *SD* = 1.72), Enjoyment in Life (*M* = 4.56, *SD* = 3.36), and Sleep (*M* = 4.00, *SD* = 2.83) and least with Walking Ability (*M* = 1.11, *SD* = 1.36) and Relations with Others (*M* = 2.11, *SD* = 1.36). Overall, the average Pain Interference Score was *M* = 3.29 (*SD* = 1.39).

Table 9

Baseline Descriptive Statistics of Pain Outcome Measures (N = 13)

Pain Survey/Subscale	Outcome Measures			Scoring Interpretation
	Min, Max	***M***	***SD***	
Pain Catastrophizing Scale (PCS) (*n* = 13)				
Total PCS Score (/52)	1,41	20.00	13.73	Pain Score = 50th Percentile
Brief Pain Inventory (BPI) (*n* = 9)				
BPI Pain Items				
Worst Pain in Past 24-hours	0,7	5.11	2.03	0 = No Pain;
Least Pain in Past 24-hours	0,3	1.78	1.20	10 = Pain as bad as you can
Average Pain	2,6	4.11	1.69	imagine
Pain Right Now	1,6	3.33	1.50	
BPI Pain Severity (3-items)	**3.00, 5.67**	**4.10**	**1.01**	
BPI Pain Interference Items				
General Activity	0,6	3.33	2.00	
Mood	4,10	6.22	1.72	
Walking Ability	0,4	1.11	1.36	0 = no interference;
Normal Work (incl. housework)	0,5	2.67	1.80	10 = interferes completely.
Relationships with Others	0,4	2.11	1.36	
Sleep	0,7	4.00	2.83	
Enjoyment of Life	2,10	4.56	3.36	
BPI Total Pain Interference (7-items)	**1.71, 5.43**	**3.29**	**1.39**	

Note. *BPI = Brief Pain Inventory; PCS = Pain Catastrophizing Scale*

Baseline Five-Facet Mindfulness Questionnaire (FFMQ) Outcomes

Descriptive statistics and reliability coefficients for the Five Facet Mindfulness Questionnaire (FFMQ) facets are presented in Table 10. Higher values represent greater mindfulness. The Cronbach's alphas for each subscale ranged between .84 and .92 indicating sufficient internal consistency and reliability similar to findings by Baer et al. (2006, 2008). Overall, the *Non-Reactivity to Inner Experience* subscale (*M* = 2.27, *SD* = 0.74), *Non-Judging of Experience* subscale (*M* = 2.57, *SD* = 0.65), and *Acting with Awareness* subscale (*M* = 2.62, *SD* = 0.86) emerged as the lowest scored FFMQ subscales at baseline (See Table 10).

Table 10

Baseline Descriptive Statistics and Reliability Coefficients for FFMQ (N = 22)

Scale/Subscale	Total Scale Score		Average Subscale Score (/5)		Cronbach's α
	M	***SD***	***M***	***SD***	
FFMQ					
Observing/Noticing (/40)	25.09	8.31	3.13	1.04	.92
Describing (/40)	25.73	7.16	3.22	0.89	.89
Acting with Awareness (/40)	20.95	6.89	2.62	0.86	.91
Non-Judging of Experience (/40)	20.54	5.16	2.57	0.65	.84
Non-Reactivity (/35)	15.86	5.17	2.27	0.74	.88
Total FFMQ Score	**108.18**	**19.12**			

Note. FFMQ = Five-Facet Mindfulness Questionnaire

Exploratory Analysis of Associations with Baseline PTSD Symptom Severity

EQ1: *Do certain baseline mental health profiles (e.g., PTSD + severe depression) explain PTSD symptom severity?*

Bivariate correlations were initially conducted to determine the relationship between selected demographics and mental health comorbidities with baseline PTSD symptom severity score (See Table 11). In terms of demographics, family history of mental health (r_{pb} = -.65, n = 22, $p < .01$) and self-reported general health (r_s = -.47, n = 22, $p < .05$) emerged as having a strong, negative correlation with baseline CAPS-5 PTSD symptom severity score. Those who reported <u>no</u> family history of mental health or self-reported worse overall health had significantly higher PTSD symptom severity score at baseline. In terms of psychometrics, the Beck Depression Inventory-II (r_p = .69, n = 22, $p < .01$) had the strongest correlation with CAPS-5 PTSD symptom severity score and indicated that higher levels of depression was significantly associated with elevated PTSD symptom severity ($p < .01$). Baseline anxiety was not a significant correlate of CAPS-5 PTSD score (r_p = .37, n = 22, $p > .05$), but was strongly correlated to the PCL-5 PTSD scale (r_p = .64, n =22, $p < .01$). The Five Facet Mindfulness Questionnaire subscales, *Acting with*

Awareness, (r_p = -.56, n = 22, p < .01) and *Describing* (r_p = -.48, n = 18, p < .05) emerged as having a significant negative correlation with baseline CAPS-5 PTSD symptom severity. FFMQ self-report of a reduced ability to act with awareness or an inability to describe their emotional experience was associated with increased baseline PTSD symptom severity (p < .05). The PCL-5 was strongly correlated with CAPS-5 PTSD Symptom Severity Score (r_p = .63, n = 22, p < .01) indicating the PTSD measures were similar. No other demographics (e.g., age, immigration status) or psychometric variables emerged as being significantly associated with baseline CAPS-5 PTSD symptom severity score (See Table 11).

A multiple linear regression using forward selection was conducted to investigate if baseline CAPS-5 score could be explained by correlated baseline psychometric and demographic outcomes (See Table 12). Overall, a two-predictor model emerged as significant and explained 69% of the variance in baseline CAPS-5 PTSD symptom severity at baseline, $F_{(2,19)}$ = 20.83, p < .001, R^2 = .69. Higher baseline BDI-II Depression score significantly predicted increased baseline CAPS-5 PTSD symptom severity score, β = .69, $t_{(19)}$ = 4.30, p = .001 and explained 48% of the variance in CAPS-5 PTSD symptom severity score which yielded a large effect size (Cohen's f^2 = 0.93; Cohen, 1992). Self-reported family history of mental health also emerged as a significant predictor, β = -.48, $t_{(19)}$ = -3.54, p = .002 and explained an additional 20% of the variance in baseline CAPS-5 PTSD symptom severity score (p < .02) with a moderate effect (f^2 = 0.26; Cohen, 1992). Participants who reported ***no history*** of family mental health predicted significantly higher baseline CAPS-5 PTSD Scores (p < .001). Anxiety scores, FFMQ scores, General Health Rating, and demographics did not emerge as significant predictors of baseline CAPS-5 PTSD symptom severity in the multiple regression model (p > .05).

Table 11

Pearson Product-Moment, Point Biserial, and Spearman Rank Correlation Coefficient Matrix of Associations between Baseline Demographics and Psychometric Variables with Baseline PTSD CAPS-5 Symptom Severity Score (N = 22)

	Variable/Correlation										
Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. CAPS5	1.00										
2. AGE	-.14	1.00									
3. FH	**-.65****	.15	1.00								
4. GHR	**-.47***	.26	.24	1.00							
5. LEC-5	.33	-.26	**-.48****	-.28	1.00						
6. PCL-5	**.63****	-.26	-.29	**-.47***	.15	1.00					
7. BDI-II	**.69****	-.18	-.32	**-.62****	.16	**.87****	1.00				
8. BAI	.37	-.09	-.08	-.27	.08	**.64****	**.60****	1.00			
9. FFMQ_Des	**-.48***	.13	.00	.30	.07	**-.52***	**-.61****	**-.52***	1.00		
10. FFMQ_AA	**-.56****	.05	.23	.23	.02	**-.52***	**-.71****	**-.54***	**.58****	1.00	
11. FFMQ_Total	**-.42***	-.12	.06	.36	.18	**-.56****	**-.66****	-.31	**.83****	**.51***	1.00

Note. * correlation is significant at the .05 level (2-tailed); ** correlation is significant at the .01 level (2-tailed). BAI = Beck Anxiety Index; BDI-II = Beck Depression Inventory-II; CAPS5 = Clinician-Administered PTSD Scale for *DSM-5*; EDU = Education level; FFMQ = Five-Facet Mindfulness Questionnaire; FFMQ_Des = Describing; FFMQ AA = Acting with Awareness; FFMQ Tot = Total Score; FH = Family history of mental health; GHR = Self-Reported General Health Rating; LEC-5 = Life Events Checklist; PCS = Pain Catastrophizing Scale

Table 12

Summary of Multiple Linear Regression Analysis to Predict Baseline CAPS-5 PTSD Symptom Severity Score (N = 22)

	Standardized and Unstandardized Coefficients					
Model 1	*B [95%CI]*	*SE B*	*β*	*t*	R^2	ΔF *in* R^2
(Constant)	34.15 [27.21, 41.10]	3.33		**10.26****		
BDI-II	.46 [.24, .68]	0.11	.69	**4.30****		
					.48**	**18.51****
Model 2						
(Constant)	43.26 [35.52, 50.99]	3.70		**11.70****		
BDI-II	.36 [.17, .55]	0.09	.54	**3.98****		
FHMH	-9.14 [-14.55, -3.73]	2.58	-.48	**-3.54***		
					.69**	**12.51****

Note: **p < .05, **p ≤ .01. Adj. R^2 = .65; BDI-II = Beck Depression Inventory; FHMH = family history of mental health*

Part 2: Pre-Post Analysis of CAPS-5 Outcomes after the 8-Week Intervention

> ***H1:*** *Clinically meaningful (CM) reductions in CAPS-5 scores, defined as a minimum reduction of 10 points* (Stefanovics et al., 2018)*, are expected at post-intervention.*

Paired samples *t*-tests revealed statistically significant differences ($p < .001$) in all CAPS-5 PTSD symptom severity subscales and total scores from baseline to post-intervention (See Table 13). Table 13 shows the mean and *SD* for each psychometric measure at T1 and T2 as well as the mean % change from T1 to T2 for both intention-to-treat (ITT) and per-protocol (PP) approaches. Pre-post analysis revealed a significant reduction in CAPS-5 PTSD Total Symptom Severity score from baseline to post-intervention for both ITT (ΔM = -20.09, *SD* = 13.65, t_{21} = -6.90, p = .000) and PP (ΔM = -24.56, *SD* = 10.68, t_{17} = -9.75, p = .000). Cohen's *d* was calculated at 1.60 (ITT) which equates to a large effect size based on Cohen's (2002) recommended large effect (d = .80). At post-intervention, 12 (67%) of the participants no longer met clinical diagnostic criteria for PTSD and one participant (5.6%) reported being symptom free. The results revealed that Criterion D: Negative Cognition and Mood Symptoms (ΔM = -7.59, *SD* = 5.23, t_{21} = 6.81, p = .000, d = 1.39) demonstrated the largest reduction in symptom severity followed by Criterion C: Avoidance (ΔM = -2.32, *SD* = 2.01, t_{21} = 5.41, p = .000, d = 1.16) following the 8-week intervention. Overall, the ITT results indicate that the 8-week intervention reduced PTSD symptom severity (See Table 13) by 20.09 points (42.7% reduction). This was a two-fold reduction in symptom severity which met and surpassed the hypothesized minimal clinically important difference (MCID) of a 10-point reduction.

Pre-Post Analysis of Secondary Psychometric Variables after the 8-Week Intervention

> ***H2:*** *Clinically significant reductions, defined as a reduction of 17.5%, in scores* (Button et al., 2015), *on the PCL-5, BDI-II, BAI, PCS and BPI are expected at post-intervention.*

Table 13 shows the mean and *SD* for each psychometric measure at T1 and T2, and the mean change and *SD* for each measure between T1 and T2. Paired samples *t*-tests were used to evaluate the significance of within-group changes in mean difference in measures pre-post intervention for both ITT ($n = 22$) and PP ($n = 18$) analysis. Boxplots revealed one outlier score (for BAI) that was more than one and a half box-lengths from the upper and lower quartiles; it was not extreme, and included in the analyses. Shapiro-Wilk's test did not reveal non-normality. There were significantly meaningful reductions in symptom severity found for PCL-5, $t_{21} = 6.44$, $p = .000$, BDI-II, $t_{21} = 5.59$, $p = .000$; BAI, $t_{21} = 4.94$, $p = .000$; PCS, $t_{12} = 3.22$, $p = 0.01$, BPI Severity, $t_6 = 2.71$, $p = .04$ and BPI Interference, $t_6 = 3.20$, $p = .02$, and FFMQ, $t_{21} = -5.00$, $p = .000$. As shown in Table 10, effect sizes (Cohen's *d*) of significant improvements (ITT) ranged from 0.75 to 1.27, indicating a large effect, with PCL-5 exhibiting the largest reduction ($d = 1.27$), followed by BAI ($d = 0.99$), FFMQ ($d = 0.88$), and BDI-II ($d = 0.83$). At post-intervention 14 participants (77.8%) reported subthreshold PTSD as measured by PCL-5. Significant improvements in secondary psychometric outcome measures ranged from 17.5%-45.6% and met and exceeded the MCID for symptom improvement (Button et al., 2015). Thus, hypotheses 2 and 3 were supported.

Table 13

Pre (T1) and Post-Intervention (T2) Mean and SD Values for Psychometric Variables for Intention to Treat (N = 22) and Per Protocol Analysis (N = 18)

	ITT[a]						*PP*					
	T1 (n = 22)		T2 (n = 22)		Δ Score		T1 (n = 18)		T2 (n = 18)		Δ Score	
Psychometric Measure	*M*	(*SD*)	*M*	(*SD*)	*(%)*	*d*	*M*	(*SD*)	*M*	(*SD*)	*(%)*	*d*
PTSD (CAPS-5)												
Criterion B (Intrusion)	12.23	(2.86)	**7.77**	**(3.61)**	-36.5%	**1.37**	12.39	(2.39)	**6.94**	**(3.23)**	-44.0%	**1.92**
Criterion C (Avoidance)	5.18	(1.89)	**2.86**	**(2.21)**	-44.8%	**1.13**	5.06	(2.01)	**2.22**	**(1.83)**	-56.1%	**1.48**
Criterion D (Cognition/Mood)	17.41	(4.62)	**9.82**	**(6.95)**	-43.6%	**1.29**	16.50	(4.50)	**7.22**	**(4.39)**	-56.2%	**2.09**
Criterion E (Arousal/Reactivity)	12.27	(4.32)	**7.73**	**(4.63)**	-37.0%	**1.01**	12.22	(4.49)	**6.67**	**(4.13)**	-45.4%	**1.29**
TOTAL Symptom Severity	47.09	(9.09)	**27.00**	**(15.22)**	-42.7%	**1.60**	46.17	(9.56)	**21.61**	**(10.54)**	-53.2%	**2.44**
TOTAL Symptoms (/20)	15.68	(2.10)	**9.73**	**(5.32)**	-37.9%	**1.47**	15.33	(2.14)	**8.11**	**(4.40)**	-47.1%	**2.09**
PTSD (PCL-5)	48.14	(11.94)	**28.95**	**17.67**	-39.9%	**1.27**	45.56	(11.35)	**22.11**	**(10.23)**	-51.5%	**2.01**
Depression (BDI-II)	28.14	(13.70)	**16.27**	**(15.02)**	-42.2%	**0.83**	25.78	(13.39)	**11.28**	**(10.65)**	-56.2%	**1.34**
Anxiety (BAI)	29.68	(9.54)	**19.36**	**(11.32)**	-34.8%	**0.99**	28.33	(8.88)	**15.72**	**(7.61)**	-44.5%	**1.60**
Pain Catastrophizing (PCS)[b]	20.00	(13.73)	**10.85**	**(8.59)**	-45.6%	**0.80**	22.00	(13.59)	**11.18**	**(8.66)**	-49.2%	**0.82**
Pain Severity (BPI)[b]	4.10	(1.01)	**2.48**	**(1.68)**	-39.5%	**1.17**	4.10	(1.01)	**2.48**	**(1.68)**	-39.5%	**1.17**
Pain Interference (BPI)[b]	3.29	(1.39)	**2.10**	**(1.74)**	-36.2%	**0.75**	3.29	(1.39)	**2.10**	**(1.74)**	-36.2%	**0.75**
Five-Facet Mindfulness (FFMQ)[c]	108.18	(19.12)	**127.18**	**(23.84)**	17.6%	**0.88**	108.61	(20.32)	**131.83**	**(23.20)**	21.4%	**1.06**

Note. Significant differences are in boldface. Cohen's *d*s are reported in absolute values. *d* = Cohen's *d*; BDI-II = Beck Depression Inventory II; BAI = Beck Anxiety Inventory; CAPS-5 = Clinician-Administered PTSD Scale for *DSM*-5; FFMQ = Five Facet Mindfulness Questionnaire; HF HRV = high-frequency heart rate variability; ITT = Intention to Treat ; PP = Per Protocol; [a]Intention to Treat using last observation carried forward; [b](*n = 13)* due to addition of scale after 6-months of recruitment); [c]FFMQ subscale; higher values indicate improvement

Pre-Post Analysis of the Five-Facet Mindfulness Questionnaire (FFMQ)

H3: *Participants who complete the intervention will report clinically significant (p <.05) increases in the Five Facet Mindfulness Questionnaire (FFMQ) scores.*

Table 14 summarizes the paired samples *t*-tests used to evaluate the significance of within-group changes in FFMQ measures for both ITT (n = 22) and PP analysis (n = 18). Significant improvements in FFMQ subscales *Acting with Awareness* (t_{21} = 4.20, p = .000, d = 0.64), *Non-Judging of Inner Experience* (t_{21} = 3.26, p = .004, d = 0.96), and *Non-Reactivity* (t_{21} = 6.21, p = .000, d = 0.83) were found. Total FFMQ score significantly improved at follow-up compared to baseline (t_{21} = 5.00, p = .000, d = 0.88). As shown in Table 14, **H3** was partially supported with three subscales (60%) reaching significance and effect sizes (Cohen's d) of significant improvements ranging from 0.64 to 0.96, indicating a medium to large effect. Overall, *Non-Judging of Inner Experience* subscale exhibiting the greatest improvement (d = 0.96), followed by *Non-Reactivity* (d = 0.83), Total FFMQ Score (d = 0.88), and A*cting with Awareness* (d = 0.64). *Observing* and *Describing* subscales had no significant changes post-intervention.

Table 14

Pre-Post Scores for Five-Facet Mindfulness Questionnaire Subscales of PTSD Participants

	***ITT*[a]**						***PP***					
	T1 (n = 22)		T2 (n = 22)		Δ Score		T1 (n = 18)		T2 (n = 18)		Δ Score	
FFMQ Subscale	*M*	(*SD*)	*M*	(*SD*)	*(%)*	*d*	*M*	(*SD*)	*M*	(*SD*)	*(%)*	*d*
Observing	25.09	(8.31)	27.45	(5.86)	9.4%	0.33	24.61	(8.79)	27.50	(5.98)	11.7%	0.38
Describing	25.73	(7.16)	27.49	(6.54)	6.8%	0.26	25.75	(7.30)	28.06	(6.45)	9.0%	0.34
Awareness	20.95	(6.89)	**25.18****	**(6.37)**	**20.2%**	**0.64**	21.33	(6.86)	**26.50****	**(5.42)**	**24.2%**	**0.84**
Non-Judging	20.55	(5.16)	**26.41***	**(6.95)**	**28.5%**	**0.96**	20.33	(5.57)	**27.50***	**(7.16)**	**35.3%**	**1.12**
Non-Reactivity	15.86	(5.17)	**20.55****	**(6.05)**	**29.6%**	**0.83**	16.56	(5.11)	**22.28****	**(4.87)**	**34.5%**	**1.15**
TOTAL FFMQ	108.18	(19.12)	**127.18****	**(23.84)**	**17.6%**	**0.88**	108.61	(20.32)	**131.83****	**(23.20)**	**21.4%**	**1.06**

*Note. *p <.05, ** p<.001.* Significant differences are in boldface; *d* = Cohen's *d*; ITT = Intention to Treat; PP = Per Protocol; [a]Intention to Treat using last observation carried forward

Part 3: Analysis Psychophysiology Outcome Measures

Analysis of Heart Rate Variability Data

> ***H4:*** *Significant changes in HRV across the 25-minute lab protocol of rest, stress, and meditation are expected. Compared to rest, HRV is expected to significantly decrease during the stress phase and increase during meditation.*
>
> ***H5****: Significant overall increases in HRV are expected at post-intervention.*

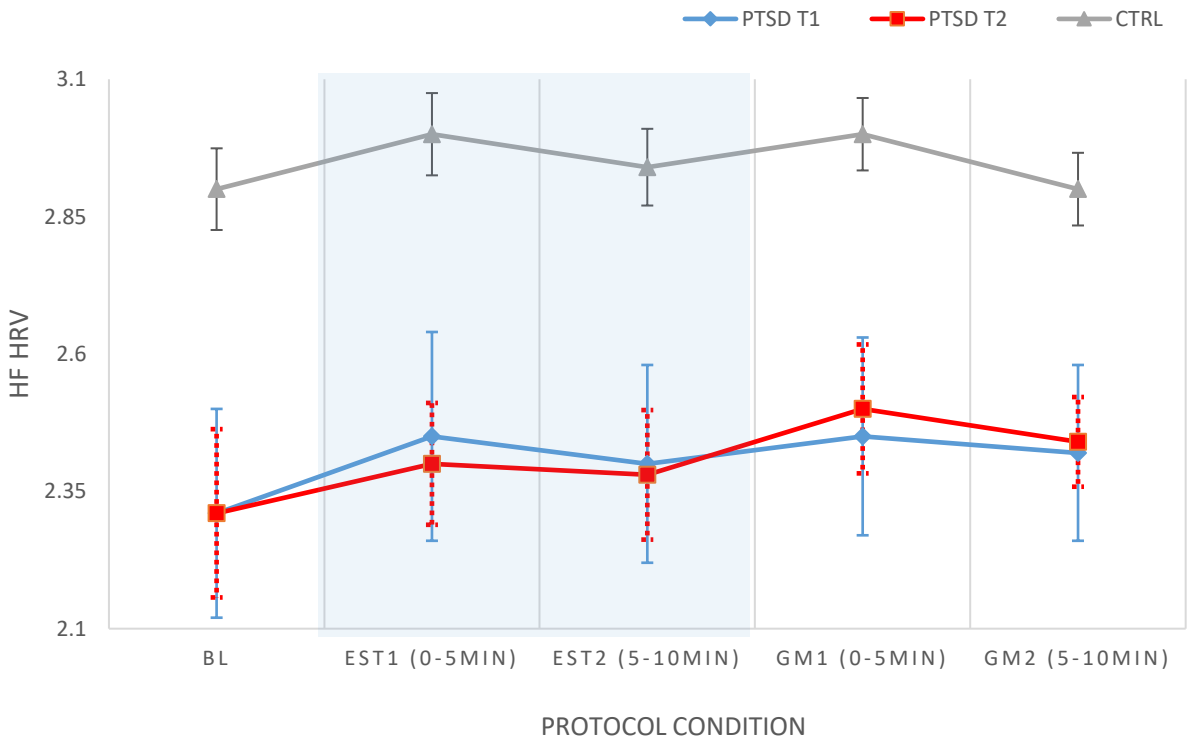
Part 3 presents the primary psychophysiology outcome data for pre-post high frequency heart rate variability (HF HRV) followed by pre-post pilot pupillometry data. Per protocol analysis was conducted to ascertain the intervention effect on psychophysiological outcomes of those who completed the intervention. Descriptive statistics of electrocardiography (ECG) variables and raw and log transformed HF HRV among PTSD participants who completed the intervention (n = 18), and the convenience sample of non-PTSD participants (n = 46) are reported in Table 15. Additional raw HRV variables are found in Appendix F. Non-PTSD participants were significantly younger in age compared to PTSD participants (p<.05). Baseline resting heart rate was significantly lower in non-PTSD participants (M = 76.45, SD = 11.09) than PTSD participants at baseline (M = 86.43, SD = 13.98, p < .01) and post-intervention (M = 84.95, SD = 10.76, p <.01).

Figure 5 displays a visual representation of the patterns of change in HF HRV across the 25-minute protocol of PTSD participants at baseline (T1) compared to post-intervention (T2), and non-PTSD participants. In accord with the visual display, non-PTSD participants appeared to have a higher HF HRV across all protocol conditions (e.g., rest, stress, meditation) compared to PTSD participants. Among the PTSD participants, a slight decrease in HF HRV during the stress protocol condition is noted at post-intervention compared to baseline HF HRV, an unexpected

finding. However, greater increases in HF HRV during meditation at post-intervention were observed particularly in the first 5-minutes of guided meditation suggesting that HF HRV increased and was sustained across the meditation condition compared to baseline. Subsequent multilevel linear mixed modelling analyses are presented to determine if significant patterns and changes in psychophysiology variables of PTSD participants from baseline to post-intervention and compared with non-PTSD participants were evident.

Figure 5

HF HRV of PTSD Participants at Baseline (T1) and Post-Intervention (T2) with Non-PTSD Participants During 25-minute Protocol Conditions of Baseline Rest, Emotional Stress, and Guided Meditation



Note. HF HRV is presented as log transformed with standard error bars. BL = baseline rest; EST = emotional image stress task; GM = guided meditation

Table 15

Estimated Marginal Means (ms2) and Log Transformed HF HRV Comparisons among PTSD Participants (n = 18) with a Non-PTSD Convenience Sample Cohort (n=46)

	PTSD Participants T1 (*n = 18)*		**PTSD Participants T2 (*n* = 18)**		**Non-PTSD Participants (*n* = 46)**	
Variable	*M(SD)*		*M(SD)*		*M(SD)*	
Age	26.39*(4.23)*		26.39(*4.23*)		20.78(*3.64*)[a,b]	
BL HR (bpm)	86.43*(13.98)*		84.95(*11.76*)		76.45(*11.09*)[a,b]	
BL Respiration	16.32*(4.09)*		16.30(*4.48*)		16.93(*2.72*)	
BL RMSSD	30.89(*26.02*)		30.14(*19.54*)		49.04(*25.69*)[a,b]	
BL LF:HF	1.84*(1.30)*		2.87*(4.08)*		1.43*(2.01)*	
			25-Minute Protocol Condition			
Variable	*EMM(SE)*	*LOG10(Sd)*	*EMM(SE)*	*LOG10(SE)*	*EMM(SE)*	*LOG10(SE)*
BL Rest Phase	708.05(*224.96*)	2.31(*0.19*)	559.79(*147.12*)	2.31(*0.18*)	1467.45(*243.20*)	2.90(*0.08*)
ES1 (0-5min)	995.50(*344.73*)	2.45(*0.19*)	490.12(*131.23*)	2.40(*0.13*)	1827.16(*310.67*)	3.00(*0.08*)
ES2 (5-10min)	810.08(*264.90*)	2.40(*0.18*)	460.78(*103.26*)	2.38(*0.14*)	1446.24(*232.66*)	2.94(*0.07*)
GM1 (0-5min)	774.59(*207.90*)	2.45(*0.18*)	810.19(*357.26*)	2.50(*0.14*)	1547.99(*217.75*)	3.00(*0.07*)
GM2 (5-10min)	580.94(*150.65*)	2.42(*0.16*)	408.61(*87.78*)	2.44(*0.10*)	1220.34(*175.18*)	2.90(*0.07*)

Note. Independent t-tests and pairwise comparisons using Bonferroni correction used to detect differences in means; [a]significant difference ($p < .05$) between Non-PTSD and PTSD T1; [b] significant difference ($p < .05$) between Non-PTSD and PTSD T2; EMM = Estimated Marginal Means (ms^2); SE = Standard Error; BL HR = baseline resting heart rate; ES = Emotional image stress task; GM = guided meditation; PTSD = posttraumatic stress disorder; RMSSD = root mean square of successive differences between normal heartbeats

Multilevel Linear Mixed Modelling Statistical Analysis for HF HRV

Analysis #1: Changes in HF HRV Pre-Post Intervention among PTSD Participants (n = 18).

> ***H4:*** *Significant changes in HRV and pupillometry across the 25-minute lab protocol of rest, stress, and meditation are expected. Compared to rest, HRV is expected to significantly decrease during the stress phase and increase during meditation.*
>
> ***H5****: Significant overall increases in HRV are expected at post-intervention.*

Prior to conducting linear mixed effects (LME) modelling procedures, graphical inspection of the data was conducted to determine discernable patterns over time for the repeated measures (See Appendix G). Subsequent independent *t*-tests were conducted to compare differences between those who withdrew from the intervention ($n = 4$) compared with those who did not. No significant differences were found at baseline ($p > .05$) and the results presented are based on per protocol (PP) analysis to determine the intervention effect (See Appendix H).

To assess the changes in HF HRV from pre- to post-intervention, a multilevel LME model procedure was conducted on PTSD participants who completed the 25-minute protocol ($n = 18$). Repeated and fixed factors identified in the LME model included the pre-post phase (e.g., baseline vs. post-intervention) and protocol condition (e.g., baseline rest 0-5mins, emotional stress task (ES) 0-5 mins, ES 5-10 minutes, Guided Meditation (GM) 0-5 mins, GM 5-10 mins) as the within-person repeated measures and between person fixed factors. The subject intercept slope was identified as the random effect. Prior to analysis, HF HRV was assessed for normality and results revealed a positively skewed distribution. Thus, the log10 transformation of HF HRV was calculated and used as the dependent variable in the LME analysis. Significant main effects of pre-post phase and protocol condition were evaluated with pairwise comparisons using a Bonferroni Type I error rate correction. Post-hoc analyses using paired samples *t*-tests were

conducted to differentiate where significant differences emerged. The summary of model effects is presented in Table 16 and parameter estimates in Table 17.

Results revealed a significant main effect of protocol condition (e.g., BL, ES 0-5 min, ES 5-10 min, GM 0-5 min, GM 5-10 min) on HF HRV ($F_{4, 221}$ = 6.41, p = .000, η^2 = .10). Pairwise comparisons using Bonferroni Type 1 correction revealed a significant difference between protocol conditions of baseline rest (0-5 min) and guided meditation (GM) 0-5 min ($p < .05$). Post-hoc analyses revealed a significant increase in HF HRV during the first 5-minutes of GM compared to baseline rest condition at both pre- (ΔM = 0.14, SD = 0.25, p = .03) and post- (ΔM = 0.19, SD = 0.30, p = .01) intervention. Further, the main effect of protocol condition remained significant while controlling for respiration rate ($F_{4, 93}$ = *2.83*, p = .03, η^2 = .10) suggesting that the differences between baseline rest 0-5mins and GM 05-mins were not attributed to respiration as a covariate ($p > .05$). The main-effect of pre-post phase (p = .82) on HF HRV was not significant and our hypothesis was not supported.

Table 16

Mixed Model Summary of HF HRV among PTSD Participants (n = 18)

Model Parameters	***df_n***	***df_d***	***F***	***P***	***η^2***
Fixed Effects					
Intercept	**1**	**17.02**	**262.86**	**.000**	**.94**
Protocol Time	**4**	**111.92**	**3.04**	**.02**	**.10**
PrePost	1	28.87	.02	.89	--
PrePost*ProtocolTime	4	102.65	.18	.95	--

Note. AIC = 141.36

Table 17

Parameter Estimates from Multilevel Linear Mixed Modelling of HF HRV

Parameter	*B [95%CI]*	*SE*	*t*	*p*	*Wald Z*	*p*
Fixed Effects						
Intercept	**2.31 [1.97, 2.65]**	**.16**	**14.08**	**.000**		
Pre-Post Phase						
Baseline[a]						
Post-Intervention	-.00 [-.25, .24]	.12	-.04	.97		
Protocol Condition						
BL[a]						
ES1	.14 [-.03, .32]	.09	1.63	.11		
ES2	.09 [-.10, .28]	.10	.91	.36		
GM1	.14 [-.06, .33]	.10	1.35	.18		
GM2	.08 [-.11, .29]	.10	.87	.39		
PrePost*Protocol						
All interactions	*ns*	*ns*	*ns*	*ns*		
Random Effects						
Intercept	**.39 [.20, .77]**	**.14**			**2.89**	***.004***
Repeated Measures						
AR1 diagonal	**.09 [.07, .12]**	**.01**			**7.26**	***.000***
AR1 rho	**-.49 [-.62, -.33]**	**.08**			**-6.50**	***.000***

Note. AIC = 141.36; **Bold text indicates significant finding.** [a]Reference parameter. AR = Auto-regressive covariance structure; BDI = Beck Depression Index; BL = baseline; ES = emotional image stress task; GM = guided meditation

Analysis #2: Exploratory Analysis of Baseline Depression as a Covariate of HF HRV Among PTSD Participants

> ***EQ2:*** *Do certain mental health profiles (e.g., PTSD + severe depression) moderate psychophysiology measures before and after an 8-week online CBT-MY intervention?*

Exploratory covariate analysis was conducted using LME modelling to assess whether the main effects of protocol condition and pre-post phase on HF HRV remained stable after controlling for baseline BDI-II depression score. Baseline BDI-II emerged as the strongest predictor of baseline PTSD symptom severity and exploratory analyses were conducted to determine if treatment

effects were moderated by comorbid depression severity. The summary of model effects is presented in Table 18 and parameter estimates in Table 19. The results of the final model revealed a significant main effect of protocol condition ($F_{4,89}$ = 2.90, p = .03, η^2 = .12) and pre-post phase ($F_{1,33}$ = 6.61, p = .02, η^2 = .17) on HF HRV. Interaction effects were conducted and confirmed a significant interaction effect of baseline depression score ($F_{1,15}$ = 22.00, p = .000) on total HF HRV and yielded a large effect (η^2 = .35). To examine interaction effects, PTSD participants were stratified into a dichotomous variable based on baseline BDI-II score (e.g., 0 = BDI-II < 26, 1 = BDI-II ≥ 26). Post-hoc analysis using independent *t*-tests revealed that those who started the intervention with more severe depression scores (BDI-II ≥ 26, n = 9) showed a significantly lower overall HF HRV at post-intervention (ΔM = -.55, SE = .24, t_{15} = 2.29, p = .04) compared to those with moderate depression (BDI-II <26, n = 9). Across the five protocol conditions, the only significant difference in HF HRV was found at post-intervention during the guided meditation phases (p < .05). Those with more severe depression (BDI-II ≥ 26, n = 9) had significantly lower HF HRV during the first 5-minutes of GM (ΔM = -.60, SE = .26, t_{16} = 2.32, p = .03) and last 5-minutes of GM (ΔM = -.44, SE = .18, t_{15} = 2.44, p = .03) compared to those with moderate depression (BDI-II < 26) suggesting that the severity of co-morbid depression blunts the meditative effect. Figure 6 depicts the differences in pre- to post-intervention HF HRV among PTSD participants with co-morbid depression. While non-significant, participants who began the intervention with the more severe depression (BDI-II ≥ 26) showed greater increases in HF HRV towards significance at post-intervention (Figure 6).

Table 18

Linear Mixed Model Covariate Analysis and Interaction Effects Summary for HF HRV Among PTSD Participants (n = 18)

Model Parameters	df_n	df_d	*F*	*p*	η^2
Intercept	**1**	**16.00**	**74.17**	**.000**	**.82**
Protocol Condition	**4**	**88.75**	**2.93**	**.03**	**.12**
PrePost	**1**	**33.26**	**6.61**	**.02**	**.17**
BL_BDI	1	16.00	1.68	.21	--
PrePost*BDI	**1**	**33.47**	**9.00**	**.01**	**.21**

Note. Model 1 AIC = 147.53; dependent variable = log10 HRV; covariate BDI-II evaluated at = 25.71 **Bold text indicates significance p < .05**; BL = Baseline; BDI = baseline Beck Depression Index score; HF HRV = high frequency heart-rate-variability

Table 19

Parameter Estimates of Covariate Mixed Model Analysis HF HRV Among PTSD Participants (n = 18)

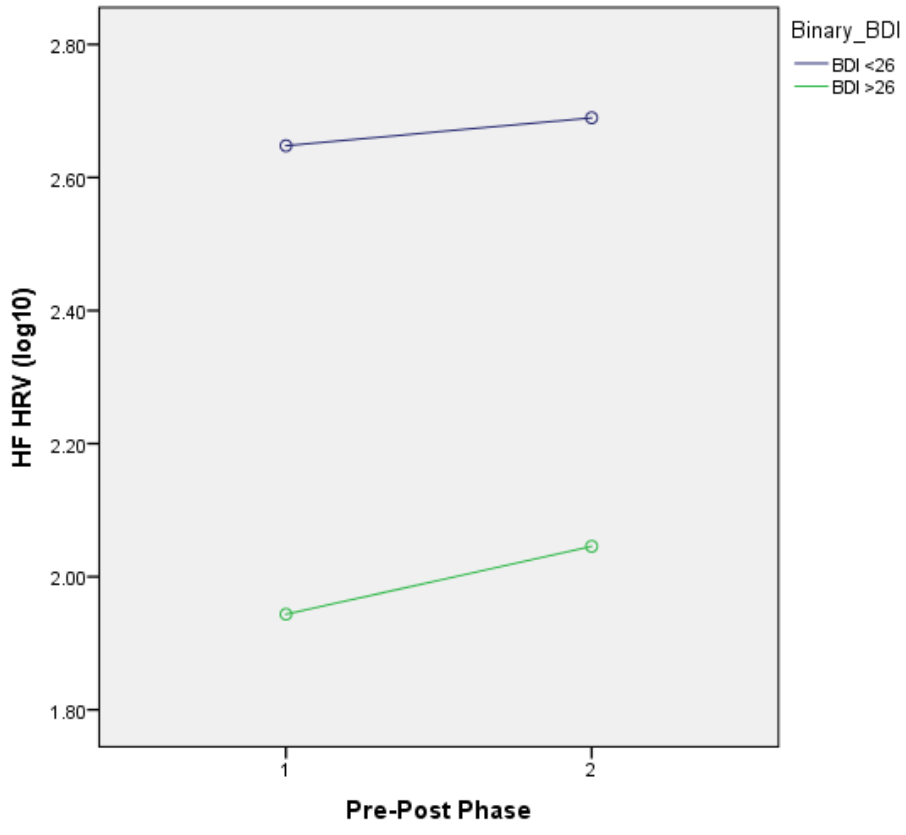
Parameter	***B [95%CI]***	***SE***	***t***	***p***	***Wald Z***	***p***
Fixed Effects						
Intercept	**2.86 [2.17, 3.56]**	**.33**	**8.64**	**.000**		
Pre-Post Phase						
Baseline[a]						
Post-Intervention	**-.36 [-.64, -.07]**	**.14**	**-2.57**	**.02**		
Protocol Condition						
BL[a]						
ES1	**.12 [.01, .22]**	**.05**	**2.21**	**.03**		
ES2	.07 [-.03, .17]	.03	1.41	.16		
GM1	**.15 [.05, .25]**	**.05**	**3.10**	**<.01**		
GM2	**.13 [.03, .23]**	**.05**	**2.56**	**.01**		
Covariate						
BL_BDI	-.02 [-.05, .00]	.01	-1.90	.07		

Interaction Effect						
Baseline*BDI[a]						
Post-Intervention*BDI	**.014 [.01, .02]**	**.00**	**3.00**	**<.01**		
Random Effects						
Intercept	**.38 [.19, .76]**	**.13**			**2.80**	**<.*01***
Repeated Measures						
AR1 diagonal	**.08[.06, .10]**	**.01**			**7.69**	**<.*01***
AR1 rho	**-.43 [-.57, -.26]**	**.08**			**-5.33**	**<.*01***

Note. AIC = 147.53; **Bold text indicates significant finding.** [a]Reference parameter. Covariate BDI-II evaluated at = 25.71; AR = Auto-regressive covariance structure; BDI = Beck Depression Index; BL = baseline; ES = emotional image stress task; GM = guided meditation

Figure 6

Change HF HRV from Baseline to Post-Intervention Stratified by Baseline BDI-II Depression Score



Analysis #3: Comparison of HF HRV among PTSD Participants (n = 18) with Non-PTSD Participants (n = 46)

> ***H6:*** *PTSD participants are expected to show significantly lower HRV at baseline only compared to cross-sectional data of a convenience sample of non-PTSD participants. Post-Intervention outcome measures will be non-significant.*

To assess whether HF HRV changes in PTSD participants were significantly different when compared with non-PTSD participants, a multilevel LME model on HF HRV was conducted with all 64 participants (PTSD participants (n = 18) and non-PTSD participants (n = 46)) that completed the 25-minute computer protocol. Fixed factors of the multilevel LME model were identified as treatment group (e.g., PTSD participants vs. Non-PTSD participants), pre-post phase (baseline vs. post-intervention), and protocol condition (e.g., 0 = baseline rest, 1 = emotional stress task (ES) 0-5min, 2 = ES 5-10 min, 3 = guided meditation (GM) 0-5min, 4= GM 5-10min). Since the non-PTSD convenience sample cohort only completed the 25-minute protocol at a single time-point the data were coded as 0 = baseline/pre and 0 = did not receive the PTSD intervention. For the within-person repeated measures, pre-post measures for PTSD participants (baseline vs. post-intervention) and protocol condition (e.g., baseline, emotional stress task (ES) 0-5min, ES 5-10min, guided meditation (GM) 0-5min, GM 5-10) were identified. The subject intercept slope was identified as the random effect.

The summary of model effects are presented in Table 20 and parameter estimates in Table 21. Results revealed a significant main effect of treatment group ($F_{1,65}$ = 14.54, p = .000, η^2 = .10) and 25-min protocol condition ($F_{4,\ 240}$ = 6.33, p = .000, η^2 = .18) on HF HRV. For the main effect of treatment condition (e.g., PTSD intervention vs. Non-PTSD participants), pairwise comparisons using Bonferroni Type 1 correction revealed that the Non-PTSD participants had a

significantly higher mean HF HRV overall than PTSD participants (B = .55, SE = 0.14, $t_{65.16}$ = 3.81, p = .000). Post-hoc independent t-tests revealed that non-PTSD participants had a significantly higher mean HF HRV ($p < .05$) across all five protocol conditions compared to PTSD participants at baseline and at post-intervention, and the differences yielded a large effect (Cohen's $d > 0.8$). Further, the differences in HF HRV between PTSD participants and non-PTSD participants remained significant ($F_{4, 238}$ = 7.70, p = .000, η^2 = .11) after controlling for respiration indicating the differences found were not due to influences of respiration rate.

For the main effect of protocol condition (e.g., BL, ES 0-5 min, ES 5-10 min, GM 05-min, GM 5-10 min) results revealed a significantly higher HF HRV during the first 5-minutes of the ES condition (B = .11, SE = 0.03, $t_{238.50}$ = 3.59, p = .000), the first 5-minutes of the GM condition (B = .14, SE = 0.03, t_{258} = 4.67, p = .000), and the last 5-minutes of the GM condition (B = .08, SE = 0.03, t_{287}= 2.64, p = .01) compared to baseline rest condition. Pairwise comparisons using Bonferroni Type 1 correction revealed that the main effect of protocol condition was largely attributed to the non-PTSD convenience cohort. Non-PTSD participants had a significantly higher HF HRV during the first 5-minutes of the ES condition compared to baseline rest condition (ΔM = .104, SE = .03, $p < .01$) and the last 5-minutes of the ES (ΔM = .07, SE = .01, $p < .02$). Non-PTSD participants had a significantly higher HF HRV than PTSD participants during the first 5-minutes of GM compared to the last 5-minutes of GM (ΔM = .10, SE = .03, $p < .05$). No other significant differences were found ($p > .05$). No significant main effect of pre-post (e.g., baseline vs. post-intervention) phase was found between baseline and post-intervention among PTSD participants (p = .87) confirming prior analysis demonstrating there was no significant intervention effect on HF HRV among PTSD participants.

Table 20

Mixed Model Summary for HF HRV Comparisons of PTSD Participants (n = 18) with Non-PTSD Participants (n = 46)

Model Parameters	df_n	df_d	***F***	***P***	η^2
Fixed Effects					
Intercept	**1**	**65.13**	**1381.10**	**.000**	**.95**
Protocol Time	**4**	**240.71**	**6.33**	**.000**	**.10**
PrePost	1	57.23	.17	.68	--
Treatment	**1**	**65.16**	**14.54**	**.000**	**.18**

Note. AIC = 179.93

Table 21

Mixed Model Parameter Estimates of HF HRV Among PTSD and Non-PTSD Participants

Parameter	***B [95%CI]***	***SE***	***t***	***p***	***Wald Z***	***p***
Fixed Effects						
Intercept	**2.32 [2.07, 2.56]**	**.12**	**18.77**	**.000**		
Treatment Group						
PTSD Intervention[a]						
Non-PTSD Ps	**.55 [.26, .84]**	**.14**	**3.81**	**.000**		
Pre-Post Phase						
Baseline[a]						
Post-Intervention	.02 [-.09, .16]	.06	.411	.68		
Protocol Condition						
BL[a]						
ES1	**.11 [.05, .16]**	**.03**	**3.59**	**.000**		
ES2	.05 [-.00, .11]	.03	1.82	.070		
GM1	**.14 [.08, .20]**	**.03**	**4.67**	**.000**		
GM2	**.08 [.02, .14]**	**.03**	**2.64**	**.009**		
Random Effects						
Intercept	**.25 [.17, .36]**	**.05**			**5.35**	***.000***
Repeated Measures						
AR1 diagonal	**.06 [.05, .07]**	**.01**			**10.52**	***.000***
AR1 rho	**-.51 [-.61, -.39]**	**.06**			**9.45**	***.000***

Note. AIC = 179.93; **Bold text indicates significant finding.** [a]Reference parameter. AR = Auto-regressive covariance structure; BDI = Beck Depression Index; BL = baseline; ES = emotional image stress task; GM = guided meditation

Analysis of Pilot Pupillometry Data

> ***H4:*** *Significant changes in pupillometry across the 25-minute lab protocol of rest, stress, and meditation are expected. Compared to rest, Peak pupil dilation (PPD) is expected to significantly increase during stress and decrease during meditation.*
>
> ***H5****: Significant overall reductions in PPD are expected at post-intervention.*

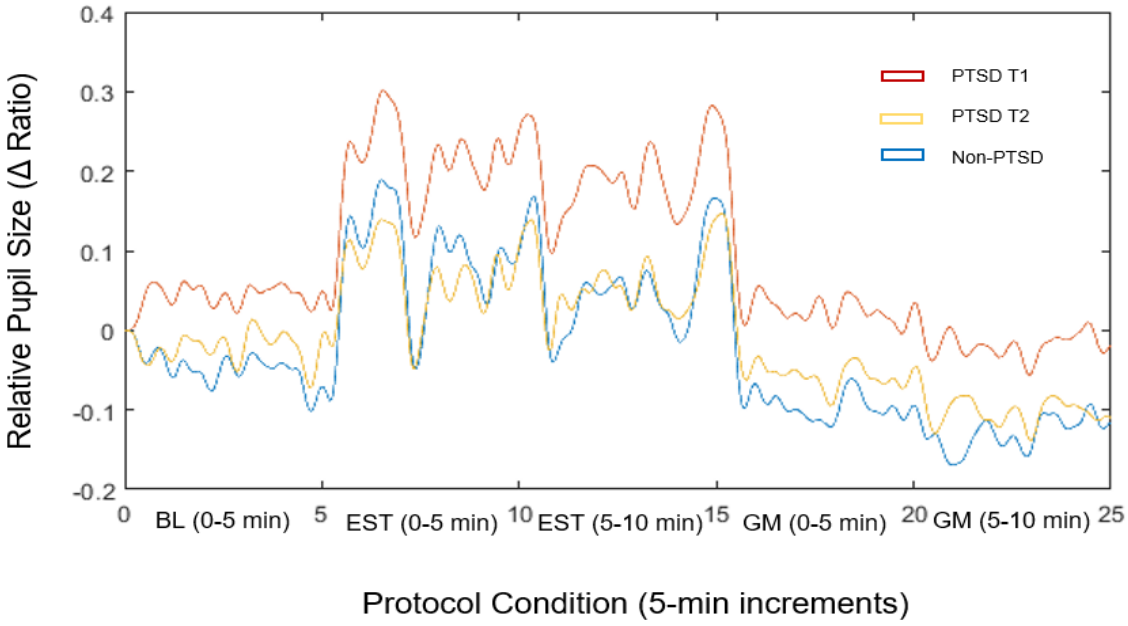
Figure 7 presents a visual representation of the fluctuations in relative pupil diameter size across the entire 25-minute protocol. The relative pupil size significantly changed across the three phases with the ES phases showing the greatest increases in relative peak pupil dilation (PPD) reflecting higher autonomic reactivity responses. Overall, during baseline testing, PTSD participants who had both pre- and post-assessments showed higher relative increases in pupil size compared to post-intervention and with non-PTSD participants, reflective of a higher autonomic reactivity (see Figure 7). Compared to non-PTSD participants, PTSD (n = 17) participants at post-intervention appeared to have lower relative pupil change during the ES phases, whereas baseline and GM phases appeared similar to non-PTSD participants (Figure 7).

Autonomic pupil reaction via peak pupil dilation (PPD) were captured during the first 500ms of the onset of the image stimulus (e.g., fixation cross or emotional image). PPD, reflecting autonomic activation, was used as the pupillometry outcome measure in pre-post statistical analyses. Descriptive statistics of mean PPD outcome variables among PTSD participants (n = 18) when compared with non-PTSD participants (n = 18) are reported in Table 22. Due to a mechanical error of the Tobii Pro Glasses 2, data from one PTSD participant at 8-week follow-up was excluded from analysis. The PTSD participants (n = 17) for whom baseline data were collected had higher PPD across all protocol conditions when compared with non-

PTSD participants, which was expected. Linear mixed effects modelling (LME) was subsequently used to determine where significant differences in PPD emerged.

Figure 7

Fluctuations in Relative Pupil Diameter Size Across the 25-Minute Protocol

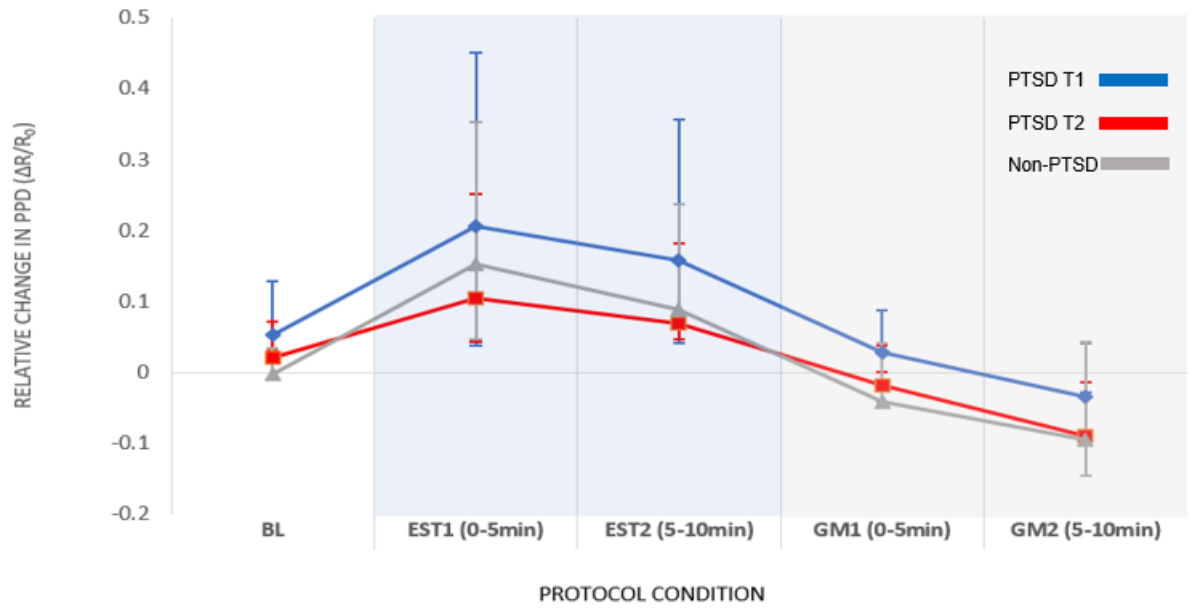


Note. *Relative pupil size is presented as a ration and is a unitless value. BL = baseline rest phase; EST = emotional image stress task; GM = guided meditation*

Figure 8 presents a visual representation of the PPD in the first 500ms of the onset of an emotional image compared to resting pupil size (value set at 0) among PTSD participants at baseline and post-intervention compared with a convenience sample of non-PTSD participants. The visual display shows preliminary evidence that PTSD participants at baseline had a larger relative PPD across the entire 25-minute protocol compared to Non-PTSD participants, but post-intervention results looked similar. Hypothesis testing follows to confirm whether these changes are significant. Additional exploratory pupil response measures during epochs of 1 s, 10 s are presented in Appendix I.

Figure 8

Peak Pupil Dilation of PTSD Participants at Baseline (T1) and Post-Intervention (T2) compared with Non-PTSD Participants During a 25-minute Protocol of Rest, Stress, and Meditation



Note. PPD is presented as relative pupil size and expressed as a ratio (0.10 = 10%) with 95% CI bars. BL = baseline rest phase; EST = emotional image viewing task; GM = guided meditation

Table 22

Relative Peak Pupil Dilation (PPD) at 500ms Across a 25-Minute Protocol among PTSD Participants and Non-PTSD Participants

	PTSD T1 (*n* = 18)		**PTSD T2 (*n* = 17)**		**Non-PTSD (*n* = 18)**	
			PPD 25-Minute Protocol			
	M	***SD***	***M***	***SD***	***M***	***SD***
BL Rest Phase	0.05	*.05*	0.02	*.07*	**-0.00**	***.06*[a]**
ES1 (0-5min)	0.21	*.09*	0.10	*.09*	0.15	*.10*
ES2 (5-10min)	0.16	*.10*	0.07	*.10*	0.09	*.13*
GM1 (0-5min)	0.03	*.07*	-0.02	*.08*	**-0.04**	***.09*[a]**
GM2 (5-10min)	-0.04	*.10*	-0.09	*.08*	-0.10	*.10*

Note. *PPD values are presented as relative change from zero; a 0.10 change reflects a 10% increase in PPD; [a]significant difference (p<.05) between non-PTSD and PTSD T1; BL = Baseline; ES = Emotional image stress task; GM = guided meditation*

Multilevel Mixed Modelling of Pre-Post Pupillometry Outcome Data

Analysis #1: Change in Peak Pupil Dilation among PTSD Participants (n = 18)

> ***H4:*** *Significant change in pupillometry across the 25-minute lab protocol of rest, stress, and meditation are expected. Compared to rest, peak pupil dilation (PPD) is expected to significantly increase during stress and decrease during meditation.*
>
> ***H5****: Significant overall reductions in PPD are expected at post-intervention.*

Prior to conducting multilevel linear mixed effects modelling (LME), independent t-tests were conducted to compare differences between those who withdrew from the intervention (n =4) from those who completed the intervention. No significant differences in peak pupil dilation (PPD) were found at baseline ($p > .05$) and the four withdrawals were removed from subsequent analysis. To assess changes in PPD from pre- to post-intervention among PTSD participants (n = 18), an LME model was conducted with pre-post phase (e.g., baseline vs. post-intervention) and protocol condition (e.g., 0 = baseline rest 0-5 min, 1 = ES 0-5 min, 2 = ES 5-10 min, 3 = GM 0-5 min, 4 = GM 5-10 min) identified as the within-person repeated measures and between person fixed factors. The subject intercept slope was identified as the random effect. Significant main effects of pre-post phase and protocol condition were evaluated with pairwise comparisons using a Bonferroni Type I error rate correction. Post-hoc analyses using paired sample *t*-tests were conducted to identify where significant differences emerged. The summary of model effects is presented in Table 23 and parameter estimates in Table 24.

LME modelling results revealed a significant main effect of pre-post phase on PPD ($F_{1,58}$ = 27.0, p = .000, η^2 = .32). Pairwise comparisons using Bonferroni Type 1 correction revealed a significant reduction in overall PPD at post-intervention compared to baseline (ΔM = -.06, SE = .01, p = .000) which equated to a large effect (Cohen's d = 0.90). Post-hoc analyses using paired

samples *t*-tests were conducted to determine where the greatest reductions in PPD emerged at post-intervention. Results showed the largest reductions in PPD emerged at post-intervention during the first 5-minutes of the ES task (ΔM = .11, *SD* = .09, t_{16} = 5.26, *p* = .000, *d* = 1.18) and equated to an 11% reduction in PPD reactivity, followed by a 9% reduction in PPD during the last 5-minutes of the ES task (ΔM = .09, *SD* = .09, t_{16} = 4.26, *p* = .001, *d* = .94). PTSD participants also saw a significant reduction (*p* = .05) in PPD during baseline rest (ΔM = .04, *SD* = .07, t_{16} = 2.09, *p* = .05, *d* = .58) and first 5-minutes of GM conditions (ΔM = .04, *SD* = .08, t_{16} = 2.10, *p* = .05, *d* = .55) which yielded a moderate effect. There was no significant change in PPD during the last 5-minutes of GM from pre- to post-intervention (*p* = .11). These findings mostly support our hypotheses that PTSD participants would see a significant reduction in PPD at post-intervention, with the exception of the last 5-minutes of GM (*p* > .05).

Further analysis revealed a significant main effect of protocol condition on PPD ($F_{4, 148}$ = 139.58, *p* = .000, η^2 = .79). Bonferroni corrected pairwise comparisons revealed that PPD across all protocol conditions were significantly different from each other (*p* = .000) indicating unique patterns of autonomic reactivity. Compared to baseline rest condition, PPD during the ES conditions resulted in an 8-13% increase in PPD values (*p* = .000). GM conditions resulted in a 4-10% reduction in PPD compared to baseline rest (*p* = .000). The greatest difference in PPD was found between the first 5-minutes of ES and last 5-minutes of GM (ΔM = .23, *SE = .01*, *p* = .000) which equated to a 23% difference in PPD.

Table 23

Mixed Model Summary for Peak Pupil Dilation (PPD) among PTSD Participants (n = 18)

Model Parameters	df_n	df_d	***F***	***P***	η^2
Fixed Effects					
Intercept	1	34.35	1.58	.22	--
Protocol Time	**4**	**148.00**	**139.58**	**.000**	**.79**
PrePost	**1**	**58.47**	**27.00**	**.000**	**.32**

Note. AIC = -577.35

Table 24

Mixed Model Parameter Estimates of PPD among PTSD Participants (n = 18)

Parameter	***B [95%CI]***	***SE***	***t***	***p***	***Wald Z***	***p***
Fixed Effects						
Intercept	**.03 [.00, .07]**	**.02**	**2.19**	**.03**		
Pre-Post Phase						
Baseline[a]						
Post-Intervention	**-.06 [-.08, -.04]**	**.01**	**-5.20**	**.000**		
Protocol Condition						
BL[a]						
ES1	**.13 [.11, .15]**	**.01**	**11.38**	**.000**		
ES2	**.08 [.05, .10]**	**.01**	**6.80**	**.000**		
GM1	**-.04 [-.06, -.02]**	**.01**	**-3.57**	**.000**		
GM2	**-.10 [-.12, -.08]**	**.01**	**-9.15**	**.000**		
Random Effects						
Intercept	**.01 [.00, .01]**	**.00**			**3.65**	***.000***
Repeated Measures						
AR1 diagonal	**.00 [.00, .00]**	**.00**			**10.23**	***.000***
AR1 rho	**-.21 [-.36, -.04]**	**.08**			**-2.51**	***.012***

Note. AIC =-577.35; **Bold text indicates significant finding.** [a]Reference parameter. AR = Auto-regressive covariance structure; BDI = Beck Depression Index; BL = baseline; ES = emotional image stress task; GM = guided meditation

Analysis #2: Exploratory Analysis of Depression as a Moderator of Pupillometry Among PTSD Participants from Baseline to Post-Intervention (n = 18)

> ***EQ2:*** *Do certain mental health profiles (e.g., PTSD + severe depression) moderate psychophysiology measures before and after an 8-week online CBT-MY intervention?*

Exploratory analysis of baseline BDI-II depression score as a covariate of PPD among PTSD participants was conducted using LME modelling. The summary of the final model effects is presented in Table 25 and parameter estimates in Table 26. Results indicated the significant main effect of protocol condition ($F_{4,87}$ = 74.76, p = .000, η^2 = .79) and pre-post phase ($F_{1,48}$ = 24.77, p = .000, η^2 = .34) on PPD remained stable. A significant interaction effect of baseline BDI-II depression score on pre-post PPD was found ($F_{1,49}$ = 7.17, p = .01, η^2 = .34) indicating that depression score moderated changes in PPD from baseline to post-intervention. To further examine the influence of baseline depression on PPD, BDI-II was stratified based on severity of depression score (BDI-II > 26, n = 9 vs. BDI-II < 26, n =8). Post-hoc analyses examining pre-post PPD values based on BDI-II depression score was conducted using independent samples *t*-tests. The results revealed that those who began the intervention with less severe depression (BDI-II < 26) had a 6% higher PPD overall at baseline (M = .11, SD = .04) compared to those who started with the most severe depression (BDI-II > 26; M = .05, SD = .07, t_{16} = 2.21, p =.05). This finding suggests that severe co-morbid depression may blunt autonomic reactivity via PPD. This may explain why the greatest reductions in PPD were found among less depressed participants at post-intervention (See Figure 9). Further analysis of baseline PPD across the protocol conditions revealed that those with less severe depression (BDI-II < 26) had significantly higher PPD during the last 5-minutes of ES (M = .20, SD = .06) compared to those with severe depression (BDI-II > 26; M = .11, SD = .10, t_{16} = 2.17, p < .05) which equated to an

approximate 10% difference. There was no significant difference in PPD across the protocol conditions based on depression score found at post-intervention ($p > .05$). When comparing the effect of depression on PPD with HF HRV, it appears as though those who started the intervention with the most severe depression (BDI-II > 26) had a significantly lower HF HRV (greater autonomic dysregulation) and significantly lower PPD (reduced autonomic reactivity) at baseline ($p < .05$).

Table 25

Mixed Model Covariate Analysis Summary for PPD Among PTSD Participants

Model Parameters	df_n	df_d	***F***	***p***	η^2
Fixed Effects					
Intercept	1	15.00	2.59	.13	--
Protocol Condition	**4**	**81.22**	**74.76**	**.000**	**.79**
PrePost	**1**	**48.52**	**24.77**	**.000**	**.34**
BL_BDI	1	14.99	.012	.92	--
PrePost*BDI	**1**	**48.66**	**7.17**	**.01**	**.13**

Note. Model 1 AIC = -344.25; dependent variable = relative peak pupil dilation; 0.1 = 10%; covariate BDI-II evaluated at = 26.47
Bold text indicates significance p < .05; BL = Baseline; BDI = baseline Beck Depression Index score; PPD = peak pupil dilation

Table 26

Mixed Model Covariate Analysis and Interaction Effects Parameter Estimates of PPD Among PTSD Participants

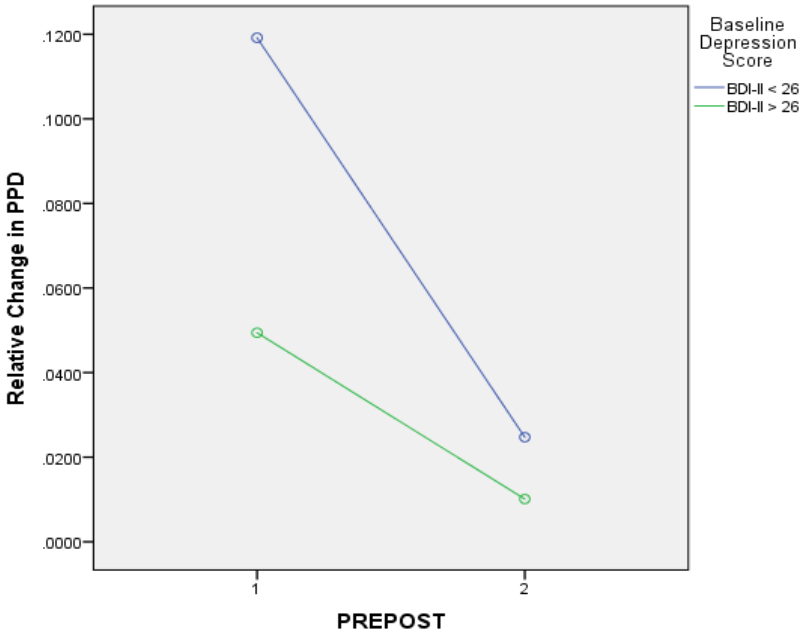
Parameter	***B [95%CI]***	***SE***	***t***	***p***	***Wald Z***	***p***
Fixed Effects						
Intercept	**.10 [.03, .18]**	**.04**	**2.88**	**.01**		
Pre-Post Phase						
Baseline[a]						
Post-Intervention	**-.12 [-.18, -.07]**	**.03**	**-4.98**	**.000**		
Protocol Condition						
BL[a]						

ES1	**.12 [.09, .15]**	**.02**	**7.95**	**.000**		
ES2	**.07 [.04, .10]**	**.01**	**4.94**	**.000**		
GM1	**-.04 [-.07, -.01]**	**.01**	**-2.51**	**.01**		
GM2	**-.11 [-.14, -.08]**	**.01**	**-7.09**	**.000**		
Covariate						
BL_BDI	-.001 [-.004, .001]	.001	-1.06	.30		
Interaction Effect						
Baseline*BDI[a]						
Post-Intervention*BDI	**.002 [.000, .004]**	**.001**	**2.68**	**.01**		
Random Effects						
Intercept	**.003 [.001, .007]**	**.001**			**2.47**	***.01***
Repeated Measures						
AR1 diagonal	**.004[.003, .005]**	**.000**			**8.57**	***.000***
AR1 rho	-.11 [-.29, .07]	.09			-1.24	*.22*

Note. AIC = -344.25; dependent variable = relative peak pupil dilation; 0.1 = 10%; covariate BDI-II evaluated at = 26.47 **Bold text indicates significance p < .05**; BL = Baseline; BDI = baseline Beck Depression Index score; PPD = peak pupil dilation

Figure 9

Interaction Effect of BDI-II Depression Score with Change in Relative PPD from Baseline to Post-Intervention



Analysis #3: Comparison of PPD among PTSD Participants (n = 18) with Non-PTSD Convenience Sample (n = 18)

> ***H6:*** *PTSD participants are expected to show significantly lower HRV and increased PPD at baseline measures only compared to cross-sectional data of a convenience sample of non-PTSD participants. Post-intervention outcome measures will be non-significant.*

Multilevel LME modelling of peak pupil dilation (PPD) was subsequently conducted with PTSD participants (n = 18) and non-PTSD convenience sample (n = 18) that completed the 25-minute protocol. Fixed factors of the LME model included treatment group (e.g., PTSD intervention vs. Non-PTSD participants), pre-post phase (e.g., baseline vs. post-intervention), and protocol condition (e.g., baseline, ES (0-5min), ES (5-10min), GM (0-5min), GM (5-10)). Pre-post phase (baseline vs. 8-weeks), and protocol condition (e.g., baseline, ES (0-5min), ES (5-10min), GM (0-5min), GM (5-10)) were entered as the within person repeated measures. The subject intercept slope was identified as the random effect. Prior to analysis, the relevant assumptions for this statistical analysis were tested satisfied. Significant main effects of treatment condition, pre-post, and protocol condition were evaluated with pairwise comparisons using a Bonferroni Type 1 error correction. Post-hoc analyses using independent *t*-tests were conducted to differentiate where significant differences emerged.

The summary of model effects and parameter estimates are presented in Tables 27 and 28. Results revealed a significant main effect of protocol condition ($F_{4,148}$ = 139.33, p = .000, η^2 = .79), pre-post phase ($F_{1,54}$ = 31.14, p = .000 , η^2 = .37), and treatment condition ($F_{1,35}$ = 6.33, p = .02 , η^2 = .15) on PPD. In terms of comparing PTSD participants with Non-PTSD participants, pairwise comparisons revealed that Non-PTSD participants had a significantly lower overall PPD compared to PTSD participants (B = -.07, t_{35} = -2.52, p = .02) reflecting reduced pupillary

reactivity. Post-hoc analyses to determine where significant differences emerged revealed that Non-PTSD participants had significantly lower PPD (*M* = .007, *SD* = .06) during baseline rest protocol condition compared to PTSD participants (*M* = .05, *SD* = .05) at baseline (t_{34} = 2.40, *p* = .02, *Hedges' g* = 0.78) indicating a large effect. Non-PTSD participants also had significantly lower PPD during the first 5-minutes of GM (*M* = -.04, *SD* = .09) compared to PTSD participants at baseline (*M* = .02, *SD* = .07, t_{34} = 2.41, *p* = .02, *Hedges' g* = 0.74) which yielded a large effect size. There was no significant difference in PPD during the ES protocol conditions between non-PTSD participants and PTSD participants at baseline (*p* > .05). At post-intervention, no significant differences in PPD between PTSD participants and Non-PTSD participants were found across any protocol condition (*p* > .05) which support our hypothesis and suggest there was an intervention effect on reduced PPD reactivity among PTSD participants.

Table 27

Mixed Model Summary for PPD among PTSD Participants (n = 18) and Non-PTSD Participants (n = 18)

Model Parameters	***df_n***	***df_d***	***F***	***P***	***η^2***
Fixed Effects					
Intercept	1	34.63	1.59	.22	--
Protocol Time	**4**	**148.03**	**139.33**	**.000**	**.79**
PrePost	**1**	**53.72**	**31.14**	**.000**	**.37**
Treatment	**1**	**34.65**	**6.32**	**.02**	**.15**

Note. AIC = -577.92 ***bold text indicates significance p < .05****; BL HRV = baseline HF HRV during baseline protocol 5-minute rest phase; BL BDI-II = baseline Beck Depression Index score; HF HRV = high frequency heart-rate-variability*

Table 28

Mixed Model Parameter Estimates for PPD Among PTSD and Non-PTSD Participants

Parameter	***Estimate [95%CI]***	***SE***	***t***	***p***	***Wald Z***	***p***
Fixed Effects						
Intercept	**.07 [.03, .11]**	**.02**	**3.41**	**.001**		
Treatment Group						
PTSD Intervention[a]						
Non-PTSD Ps	**-.07 [-.12, -.01]**	**.03**	**-2.52**	**.02**		

Pre-Post Phase						
Baseline[a]						
Post-Intervention	**-.06 [-.08, -.04]**	**.01**	**-5.58**	**.000**		
Protocol Condition						
BL[a]						
ES1	**.13 [.11, .15]**	**.01**	**11.37**	**.000**		
ES2	**.08 [.05, .10]**	**.01**	**6.80**	**.000**		
GM1	**-.04 [-.06, -.02]**	**.01**	**-3.58**	**.000**		
GM2	**-.10 [-.12, -.08]**	**.01**	**-9.13**	**.000**		
Random Effects						
Intercept	.005 [.003, .009]	.00			**3.57**	***.000***
Repeated Measures						
AR1 diagonal	.004 [.003, .005]	.000			**10.25**	***.000***
AR1 rho	-.21 [-.36, -.04]	.08			**-2.50**	***.013***

Note. AIC = -577.92; **Bold text indicates significant finding.** [a]Reference parameter. AR = auto-regressive covariance structure; BL = baseline; ES = emotional image stress task; GM = guided meditation; PPD = peak pupil diameter

Exploratory Analysis of PPD, HF HRV and PTSD Symptom Severity

To examine the influence of psychophysiology variables on PTSD symptom severity scores, exploratory bivariate correlations of baseline and post-intervention PPD and HF HRV outcomes with CAPS-5 and PCL-5 scores were examined to assess for significant associations. At baseline, CAPS-5 PTSD symptom severity score was significantly associated with baseline PPD at post-intervention (r_p = .65, p < .01) suggesting that the higher the CAPS-5 PTSD symptom severity score at baseline, the higher the resting PPD (increased autonomic reactivity) at post-intervention. At post-intervention, PPD during the first 5-minutes of the protocol (baseline rest condition) was significantly associated with post-intervention PCL-5 PTSD symptom severity score (r_p = .48, p < .05) suggesting that higher PPD at post-intervention was related to higher self-reported PTSD symptomology. No HF HRV variables at baseline or post-intervention significantly correlated with CAPS-5 or PCL-5 PTSD symptom severity score (p > .05).

Part 4: Program Adherence, Satisfaction and Engagement

Program Adherence

Given the novelty of the online 8-week intervention, it was important to understand the person-level factors associated with program adherence and engagement of the mindfulness-based CBT program. To evaluate program adherence, weekly attendance and length of the weekly CBT calls was recorded. In addition, weekly program engagement was self-reported by participants and self-reported 7-day recall of mindfulness and yoga was obtained at the end of the intervention. Program adherence self-report metrics are presented in Table 29. Overall, 94% of participants (n = 17) had a 100% attendance rate on the weekly CBT calls with one participant completing 7 (87.5%) of the 8 scheduled calls. On average, the CBT calls lasted a duration of 64.27mins (SD = 6.39) and ranged from 60-90 minutes depending on the needs of the client. In terms of weekly self-directed practice, time spent in guided meditation was highest (M = 38.89 mins/week, SD = 28.16), followed by yoga (M = 31.94 mins/week, SD = 28.24), and breath techniques (M = 9.89 mins/week, SD = 11.87). Combining all program intervention components, participants spent an average of 145 minutes (~3hrs) per week engaging with the intervention (SD = 40.82), which equates to approximately 20 minutes per day. When CBT calls were eliminated from this equation, participants spent 12-minutes per day in self-directed mindfulness-based practice. In total, 837 minutes (SD = 228.17) of program engagement were recorded across the entire intervention equating to a total of 14-hours of program participation (see Table 29).

Table 29

Intervention program attendance and protocol adherence of PTSD participants who completed the 8-week intervention (n = 18)

Intervention Adherence Metric	**M(*SD*)**
Attendance Rate for Counselling Calls (/8)	7.94*(0.23)*
Weekly Counselling Call Duration (mins/session)	64.27*(6.39)*
7-Day Recall of Yoga (mins/week)	31.94*(28.24)*
7-Day Recall of Guided Meditation (mins/week)	38.89*(28.16)*
7-Day Recall of Breath Techniques (mins/week)	9.89*(11.87)*
Total Weekly Self-Directed Mins (mins/week)	11.53*(22.76)*
Total Weekly Intervention Mins (mins/week)	144.99*(40.82)*
Total 8-Week Intervention (mins)	837.00*(228.17)*

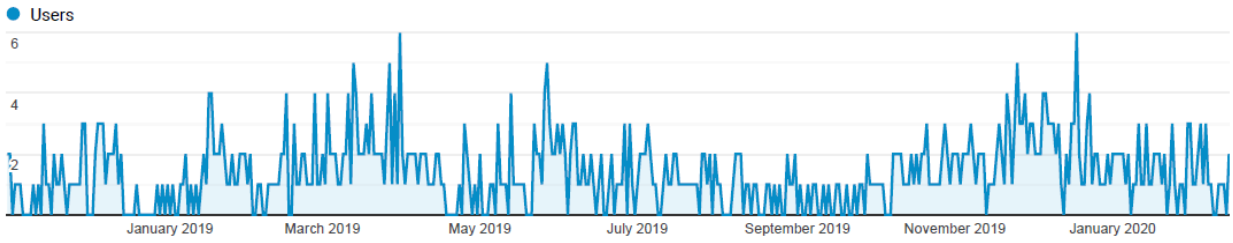
Google Analytics of Website Usage

As an added strategy, Google Analytics was linked to the intervention website to monitor online website analytics of visitors during the recruitment period from October 25, 2018 to February 15, 2020. Figure 10 depicts the daily users across the entire duration of the intervention period highlighting increased recruitment and enrollment during March 2019 and November 2019. While the weekly program modules were password protected and only made available to enrolled participants, the homepage of the website was publicly accessible making it challenging to fully isolate the Google Analytics to the intervention participants. In addition, accessing content on multiple devices (e.g., desktop, tablet, mobile phone) may affect the accuracy of the analytics. Investigating patterns of usage among "Return Users" was thought to be the most accurate given the increased likelihood that a return user was an intervention participant. Based on this logic, return users spent an average of 3 minutes and 14 seconds on the website and viewed an average of 2.13 pages during a single visit. The bounce back rate is a performance indicator that measures the percentage of people who land on a website and leave without engaging in the site. It is calculated as single-page sessions divided by all sessions or the

percentage of all sessions on a site in which users viewed only a single page and triggered only a single request to the analytics server (Google Analytics, 2020). Based on this calculation, the bounce rate was 44.91% indicating a better than average level of engagement on the site. According to Google Analytics, a higher bounce rate (>70%) indicates less engagement and time spent on the website (Google Analytics, 2020). Average time spent on each website page and total pageviews was captured and presented in Figure 10. Overall, participants spent the most amount of time on the Week 8 "Facing Forward" module (00:06:56) followed by Week 2 "The Ebb and Flow" (00:05:57). In terms of pageviews, Week 1 "Start Where You Are" had the highest proportion (11.72%) followed by Week 2 (7.84%). 50% of participants (*n* =9) continued to access the program website and weekly modules after the 8-week intervention was completed.

Figure 10

Google Analytics Data Report of Daily Website Traffic, Website Analytics and Website Engagement



	User Type	Acquisition			Behavior		
		Users	New Users	Sessions	Bounce Rate	Pages / Session	Avg. Session Duration
		109 % of Total: 28.02% (389)	0 % of Total: 0.00% (385)	982 % of Total: 71.84% (1,367)	44.91% Avg for View: 46.16% (-2.71%)	2.13 Avg for View: 2.17 (-1.51%)	00:03:14 Avg for View: 00:03:06 (4.52%)
☐	1. Returning Visitor	**109**(100.00%)	0 (0.00%)	982(100.00%)	44.91%	2.13	00:03:14

Avg. Time **Pageviews (%)**

1.	/week-8-face-forward	**00:06:56**	2.94%
2.	/week-2-ebb-flow	**00:05:57**	7.84%
3.	/week4-emotionalimprint	**00:05:17**	5.13%
4.	/traumaimpact	**00:05:03**	2.30%
5.	/week-6-second-arrow	**00:04:54**	5.44%
6.	/week-7-forgiveness	**00:04:52**	3.82%
7.	/week-3-body-has-your-back	**00:03:58**	5.88%
8.	/week-1-start-where-you-are	**00:03:44**	11.72%
9.	/week5-reclaimyourbody	**00:03:18**	4.19%
10.	/resources	**00:02:51**	7.13%

Usefulness Rating of Program Components

Usefulness of program components and overall program satisfaction was assessed at post-intervention. Participants were first asked to rate six components of the intervention from 1 = "most valuable/helpful" to 6 = "least valuable helpful." 16 (89%) of the participants rated weekly CBT calls as the most helpful program component (M = 1.35, SD = 1.19), followed by the weekly summary emails (M = 2.82, SD = 1.15, n = 8, 44.4%), and online guided meditation audios (M = 3.28, SD = 1.33). The weekly live drop-in mindfulness sessions were rated as the least helpful program component (M = 4.88, SD = 1.53) by 10 participants (55.6%). Overall, participants rated Week 5 "Embrace and Hold Space for Suffering" as the most helpful weekly module (n = 7, 38.9%), followed by Week 6 " The Second Arrow" (n = 5, 27.8%).

Program Satisfaction

In terms of program satisfaction, a series of 10 self-reported Likert-scale questions scored as, 0 = "strongly disagree" to 4 = "strongly agree," were asked to assess overall satisfaction with the mindfulness-based CBT program (See Table 30). Across all 10 questions, not a single participant reported 0 (strongly disagree) or 1 (disagree) for any of the questions with 2 (neutral) being the lowest rating. The highest rated satisfaction metrics included, "I got value out of

participating" (*M* = 3.89, *SD* = 0.32), "I learned something new about healing from PTSD that I previously did not know" (*M* = 3.83, *SD* = 0.38), and "I would participate again" (*M* = 3.83, *SD* = 0.38). 100% of participants agreed/strongly agreed that they would enrol in the clinical trial again if they had the option and believed they had a better understanding of how mindfulness can help alleviated symptoms of PTSD.

Table 30

Results from the CBT-MY Program Satisfaction Questionnaire Post-Intervention

Satisfaction Metric	***M(SD)***	**n, %**
"I believe the severity of my PTSD symptoms reduced"	3.33(0.69)	16, 88.9
"I feel better than when I started"	3.50(0.71)	16, 88.9
"I see an improvement in my health and wellbeing"	3.39(0.70)	16, 88.9
"I have a better understanding how yoga and mindfulness can help alleviate symptoms of PTSD"	3.61(0.50)	18, 100
"I enjoyed participating"	3.72(0.57)	17, 94.4
"I found the online yoga and mindfulness clinical trial helpful"	3.56(0.62)	17, 94.4
"I got value out of participating"	3.89(0.32)	18, 100
"I learned something new about healing from PTSD that I previously did not know"	3.83(0.38)	18, 100
"I am satisfied with my experience participating"	3.67(0.59)	17, 94.4
"I would participate again"	3.83(0.38)	18, 100

Note. Satisfaction scores ranged from 0 (strongly disagree) to 4 (strongly agree).

Anecdotal Written Feedback

Participants were also asked to provide personal feedback regarding their participation in the 8-week intervention to help provide additional information on future program revision and improvement (See Table 31). The majority of responses provided were positive and encouraging expressing support for the continuation of the weekly CBT calls and mindfulness strategies. While few people provided suggestions for improvement, understanding constructive feedback provides better insight for future program offerings. Of the four participants who offered suggestions for improvement, two participants indicated that access to the resources could be enhanced by offering an option to download the guided audios or make the website into a mobile

app that relied less on heavy data usage. One participant indicated that lengthening the duration of the intervention would be helpful and one participant offered a suggestion to meet with other participants.

Table 31

Anecdotal Feedback from Participants Regarding their Program Participation

Participant Written Feedback
P3 Being able to download resources (as discussed earlier) was really helpful!
P11 I am trying to think of something that I would change about the program, because I would like to be helpful, but it was perfect for me. I am incredibly grateful. Thank you so much!
P14 Extending the period of intervention time
P18 It was an amazing experience, and I hope it can reach more people and overall have the protocol be implemented for young adults as a regular part of healing. I think the website is organized well and is easy to use. The audio recordings are a life saver as well. Thank you for including me in the trial!
P20 The results are quite obvious from my weekly calls, but this program has improved my quality of life a lot. I'm very grateful I had the chance to participate.
P21 This has been an amazing experience, it has been life changing. I have learned so much about myself and I am so thankful for this opportunity. I have learned about how to reduce my stress and sit with my emotions. Most importantly, I am proud of myself as I have learned to live in my own skin for the last 8 weeks. Thank you for everything!!
P23 Make the website an app for even easier access.
P25 I have none. It was as helpful as it could be and interactive.
P28 I really found this Trial very valuable to me. I do believe the weekly coaching calls to be the most valuable part of this trial. Thank you for allowing me to participate!
P30 Thank you for offering this opportunity. It was very helpful!
P34 I loved each and every part of this trial I would say to meet others would be a great add on to it

Chapter 5: Discussion

Chapter 5 begins by summarizing the baseline sample demographics and implications for future epidemiological research. The second section discusses the pre-post psychometric outcomes and implications of the findings. The third section involves comment on the psychophysiological outcome data and their implications for future clinical studies. Chapter 5 concludes with a comprehensive overview of the study limitations and recommendations for future PTSD research.

PTSD is a complex mental health condition that impedes daily function in multiple health domains (Kessler, 2000; Kessler et al., 2017). Although significant research has supported stand-alone treatments such as CBT (Sijbrandij et al., 2016), mindfulness (Hopwood & Schutte, 2017), and yoga (Kirk et al., in press; Hopwood & Schutte, 2017; Taylor et al., 2020), there is a paucity of research testing the effectiveness of combining these approaches into an integrated online intervention. Amidst the dominance of self-report outcomes, there has also been a deficit of objective measures related to autonomic nervous system regulation in clinical samples. From a public health standpoint, research investigating scalable and accessible online PTSD treatments may help bridge a gap between those who require mental health treatment and those who actually receive it. Thus, the purposes of this research were to advance the current literature examining the utility of a potentially scalable, online CBT-MY treatment for PTSD. This study investigated associations between psychometric measurements of PTSD, depression, anxiety, and mindfulness with objective measures of pupillometry and HRV under resting, stress-induced, and guided meditation conditions, before and after an eight-week CBT-MY intervention. Primary research objectives were to ascertain the within-person changes in both self-reported psychometric and objective psychophysiological outcomes relevant to PTSD symptom reduction. Additional exploratory research objectives were to investigate if comorbid

depression moderated PTSD symptom reduction. The use of pupillometry as a novel psychophysiology marker of clinical PTSD was also explored.

Baseline Demographics and Characteristics of PTSD Participants

Young adulthood represents a complex time period where habitual health patterns are formed and can extend into older adulthood (Allender et al., 2008; Bellows-Riecken & Rhodes, 2008; Kirk & Rhodes, 2012). Research has established young adulthood as an especially important time-period for health behaviour change given the documented declines in health promoting behaviours like regular physical activity, nutrition, and mental health and wellbeing (Allender et al., 2008; Bellows-Riecken & Rhodes, 2008; Nelson et al., 2008; Kirk & Rhodes, 2012). We aimed to expand the existing literature on evidence-based PTSD treatment by exploring the effectiveness of an online intervention for a sample of young adults, ages 18-35, currently enrolled in post-secondary education who self-reported current PTSD symptoms. Recruitment efforts were not limited by type or frequency of trauma exposure and were notably inclusive of childhood developmental trauma, repeated, or multiple trauma exposures, and unique exposures (e.g., racialized trauma) not yet fully articulated in the existing literature. To date, prior intervention research has focused predominantly on war veterans returning from combat and have not focused on a community sample of young adults navigating complex life-transitions (e.g., education) while grappling with clinical PTSD symptoms. National epidemiological data tend to indicate community samples from low-socioeconomic status (SES) backgrounds are a priority target for PTSD intervention given the known link between SES and health disparity (Sedlak et al., 2010). Findings from our study suggest that young adults enrolled in post-secondary education also present a unique population in need of targeted intervention given the complexity of academic stressors on mental health.

Comparison of our data with national epidemiological PTSD data presents challenges given the variability in diagnostic instrumentation, sampling procedures, and specific changes to *DSM-5* classification of PTSD. Despite these challenges, the baseline characteristics and demographics of the participants included in this clinical trial highlighted young adults, enrolled in post-secondary education, as a unique target population for PTSD intervention. Overall, participants enrolled in this study reported a total of 11.50 (*SD* = 5.92) trauma exposures with an average of 5.14 (*SD* = 1.86) direct trauma exposures, which is a twofold increase over the Canadian national average of 2.31 (*SD* = 2.33) direct trauma exposures reported in the last national study conducted in 2008 by Van Ameringen et al. (2008). The magnitude of trauma exposure found in our study points toward a need to update the existing national PTSD prevalence data to better capture trauma exposure, and in particular, reflect the duration of trauma exposure and account for repeated exposures in Canadians. Explanations for the elevated direct trauma exposures found in our study may be the proportion of participants who reported being a landed immigrant (*n* = 10, 45.5%) and had spent an average of 12.8 years (*SD* = 11.1) in their home country prior to migrating to Canada. Many of the participants enrolled in this clinical trial reported childhood trauma exposure in combination of being born and raised in home countries characteristically known for gender-based violence and discrimination, as well as civil unrest, and threat of war (e.g., Iran, Iraq, Pakistan). Prior research by Pumariega and Rothe (2010) suggests that the process of immigration, particularly for children and youth, is linked to higher risks of psychopathology as a result of challenges associated with assimilation and acculturation (e.g., loss of familiar language, psychological distress). Extreme stress resulting from: 1) separation from immediate and extended family, 2) navigating new economic pressures and legal processes, 3) learning a new language and customs, and 4) confronting a disproportionate risk of a) exposure to racial discrimination, b) abuse by law enforcement, and c)

fear of deportation combined with d) individual childhood trauma exposure may potentially explain the severity and chronicity of PTSD found in this study (Pumariega & Rothe, 2010). In addition to the stress resulting from the process of immigration, the participants enrolled in this study were full-time university students with additional demands to navigate a new educational system, write and speak in English, and potentially face the threat of subtle and overt discrimination. Further research examining the long-term effects of immigration on PTSD symptom severity and autonomic function may be an important focus for future research given the magnitude of trauma exposure found in this study.

In addition to the magnitude of trauma exposures, another key finding was the length and duration of trauma exposure during childhood. The effects of childhood trauma extend across the lifespan and are associated with long-term detriments to health and overall functioning during adulthood (Davis et al., 2018; van der Kolk, 2017). Our findings suggest that childhood trauma may be a more prevalent experience than typically believed. Participants reported the mean age of their first memory of trauma exposure as 6.66 years (*SD* = 4.40) and a mean duration of repeated trauma exposure in childhood as 9.92 years (*SD* = 4.62). Verbal emotional and psychological trauma, reported as the most common childhood trauma exposure (84.2%), was often combined with physical and/or sexual abuse. The intensity, duration and frequency of trauma exposure found in our study challenge US national incidence of child abuse data investigated by Sedlak et al. (2010) who concluded that individuals from low SES are at greater risk of childhood trauma. Our findings of childhood trauma exposure in a university sample highlights that young adults with PTSD enrolled in post-secondary education represent another important target population for clinical PTSD intervention.

Understanding the complex factors linked to PTSD symptom severity can serve to identify appropriate intervention targets. One of the exploratory aims of this dissertation was to ascertain whether specific baseline mental health variables (e.g., severe depression) could explain the variance in baseline PTSD symptom severity and, accordingly, help identify appropriate intervention targets. The findings from our exploratory analysis revealed that comorbid depression explained 48% of the variance in CAPS-5 PTSD symptom severity score at baseline. While PTSD, as a stand-alone diagnosis, is a significant psychiatric disturbance, our findings indicate that PTSD and depression have a strong association and should not be treated in isolation. Prior research estimates that up to 50% of people diagnosed with PTSD will also have symptoms reflecting levels of clinical depression (Campbell et al., 2007). Unfortunately, accurate detection and diagnosis of clinical depression with or without PTSD remains an ongoing challenge, which means treatment is often inadequate (Campbell et al., 2007). According to Campbell et al. (2007), current guidelines and clinical best-practice typically approach depression and PTSD "as separate entities with unique pathogenesis and treatment indications" (p. 712). Given our findings on the predictive utility of depression in explaining PTSD symptom severity, treatment approaches that consider the influence of comorbid depression symptoms may help overcome known challenges like high attrition rates and treatment-resistance in existing intervention protocols (Campbell et al., 2007). The findings from our exploratory analysis adds empirical support to the literature on the effects of comorbid depression on PTSD symptom severity and considerations for future care provision. Overall, the sample examined in this dissertation appeared to present with more complex psychopathology and trauma exposures than what is currently represented in epidemiological PTSD data.

Pre-Post Psychometric Changes

The primary aim of this study was to evaluate an eight-week CBT-YM intervention in a single-arm trial on psychometric and objective psychophysiological outcomes in adults, ages 18-35 years, with self-identified and psychometrically-assessed PTSD. Overall, significant PTSD symptom reductions were found and yielded a large effect (CAPS-5 d = 1.60; PCL-5 d = 1.27) and additional large effect reductions found for depression (d = 0.83), anxiety (d = 0.99), and increases in mindfulness (d = 0.88).

PTSD, Depression and Anxiety

In terms of the primary outcome measure, PTSD symptom reductions represented a clinically meaningful change that exceeded findings from systematic reviews by Bradley et al. (2005) that focused on psychotherapy for PTSD (d = 1.43), Lewis et al. (2019) on trauma-focused CBT (d = 1.04), Bolton and Dorstyn (2015) on online psychotherapy for PTSD (d = 1.05), and a trial by Possemato et al. (2010) on therapist-guided online therapy for PTSD (d = 1.40). In addition, our findings are in line with a recent study incorporating mindfulness and yoga within an intensive 3-week program for veterans with PTSD which showed a pre-post effect size of d = 1.12 (Zalta et al., 2018). In our study, the baseline measures in depression and anxiety approximated moderate depression (M = 25.78, SD = 13.39) and severe anxiety (M = 28.33, SD = 8.88) while the post-intervention outcome means reflected minimal depression (M = 11.28, SD = 10.65) and mild-to-moderate anxiety (M = 15.72, SD = 7.61; Beck et al., 1996a; Beck & Steer, 1993). The reductions in depression and anxiety symptoms in addition to PTSD were consistent with previous studies showing similar comorbid changes after therapeutic intervention (Lewis et al., 2019; Schnurr et al., 2007; Zalta et al., 2018).

At baseline, 90.9% of participants met CAPS-5 PTSD diagnostic criteria and, at post-intervention, only 33.3% (n = 6) of participants met PTSD diagnostic criteria after 8-weeks of CBT-MY. In terms of PCL-5, 100% met PTSD symptom threshold criteria at baseline, whereas after 8-weeks of CBT-MY, only 22% (n = 4) reported symptom thresholds at or above the diagnostic threshold on PCL-5. Only one participant (5.6%) reported being completely symptom-free at post-intervention, and the remaining participants (n =11, 61%) reported subsyndromal PTSD. While notable symptom improvement was observed in our study, 8-weeks of CBT-MY only resulted in partial improvement. McFarlane et al. (2017) propose that varied PTSD trajectories (e.g., subsyndromal PTSD) impact care provision and that a clinical staging treatment strategy might be helpful. Features of symptom change across the trajectory of PTSD can help inform clinical efforts and treatment approaches by differentiating stages in relation to symptom improvement (McFarlane et al., 2017). With improved staging of PTSD, clinical efforts can become targeted towards specified participants most likely to achieve specific treatment outcomes (McFarlane et al., 2017). Accordingly, the CBT-MY intervention in this study suggests a particular utility for certain PTSD stages, but not necessarily appropriate for the most severe symptoms. As noted in our findings, participants who scored "severe to extreme" symptom presentation in *Criterion D: Negative Cognition and Mood Symptoms* (CAPS-5) were the least likely to reduce PTSD symptoms (to a subsyndromal stage), and, furthermore, withdrew from the intervention prematurely. Based on recommendations by McFarlane et al. (2017), CBT-MY is likely best suited for a less severe stage of clinical PTSD progression. Longitudinal research of subclinical-clinical stages of PTSD after trauma exposure via neurobiological markers and self-reported symptoms may also help differentiate when and how symptoms evolve. Such evidence will help determine the stages of PTSD where specific treatments are most effective (McFarlane et al., 2017). Of note, the majority of participants moved from full to

subsyndromal PTSD, supporting the utility of a CBT-MY intervention as a viable approach for symptom reduction in this majority.

Pain

The PTSD symptom criteria outlined in the *DSM-5* CAPS-5 assessment does not explicitly elicit acute or chronic pain symptom disclosures. Based on the anecdotal feedback of pain symptoms disclosed during weekly counselling sessions in our intervention, outcome measures of pain were introduced into the study six months after initial recruitment to explore the relationships between PTSD and pain. A pilot sample of 13 (59%) participants completed pain measures. At baseline, 61.5% (n = 8) of the pilot sample of participants reported current pain with self-reported headaches or neck and shoulder pain being the most commonly reported. Additionally, self-reported fibromyalgia, chronic fatigue syndrome, pelvic floor pain (e.g., PCOS, pelvic inflammatory disease), and migraines were identified. Significant large effect size reductions in pain severity (d = 1.17) and interference (d = 0.75) were found post-intervention highlighting the importance of further study examining the role of comorbid pain among young adults with PTSD. Prior research examining comorbidity between pain and PTSD have focused heavily on combat veterans, and middle-aged to older-adult populations (Katz et al., 2014), but our study indicates young adults with PTSD may be an important age stratum for targeted pain intervention. The first onset of pain symptoms may emerge during younger adulthood and may be more effectively treated before the chronicity of pain extends into middle- and older-adulthood.

Research examining the link between PTSD and chronic pain symptoms have revealed shared characteristics and response patterns such as intensified hypervigilance and attentional bias, dysregulation of physiological response to stress and pain modulation, and sustained

hyperarousal and avoidant behaviour (Katz et al., 2014; Asmundson et al., 2002). According to a comprehensive review conducted by Katz et al. (2014), comorbid chronic pain emerged as having the highest prevalence and odds ratios with PTSD in a US sample of 5,692 adults (OR = 2.6 [95% CI: 2.1, 3.3]; Von Korff et al., 2005) and in a global sample of 85,088 participants (OR = 2.6 [95%CI: 2.2, 3.0]; Demyttenaere et al., 2007). In a Canadian sample of 36,984 adults, the risk of pain was significantly higher among people with PTSD, and the prevalence rates of PTSD and fibromyalgia (7.7%), migraines (33.8%), and back pain (46%) were significant (Katz et al., 2014; Sareen et al., 2007). Katz et al. (2014) suggest that unresolved chronic pain may become a compounded traumatic stressor that contributes to the reexperiencing of difficult PTSD symptoms that impede treatment efforts. Thus, further research efforts examining the association between PTSD and pain among young adult populations is warranted and a potential public health priority.

Prior research among military war veterans with PTSD indicated that an estimated 20%-80% satisfied diagnostic criteria for current chronic pain (Katz et al., 2014; Asmundson et al., 2002; Beckham et al., 1997; White & Faustman, 1989). Among firefighters with PTSD, nearly 50% reported current pain (McFarlane et al., 1994) and in community samples with current PTSD, 20-30% reported current pain and somatic symptoms (Amir et al., 1997; Asmundson et al., 2002; Hubbard et al., 1995). The prevalence of current pain among war veterans and firefighters is expected considering the physical demands associated with the role, whereas the similar prevalence of current pain reported in our sample of university students (61.5%) warrants further investigation of the association with PTSD, psychological work demands (e.g., complex life transitions, school and work demands) and pain symptoms. Notably, large effect size reductions in pain severity (d = 1.17) and interference (d = .75) were found post-intervention highlighting the effectiveness of a CBT-MY intervention in the reduction of physical symptoms.

Mindfulness-based practices like yoga and meditation offer a philosophical and explanatory framework to facilitate the restoration of inner coherence and well-being, and modulation of immune function, inflammation, and better chronic pain management (Sullivan et al., 2018). While reductions in pain were evident following the CBT-MY intervention, the findings must be interpreted with caution due to the small sample size, potential social desirability bias, and that differences between acute and chronic pain were not precisely captured. Nonetheless, examining the association of PTSD and chronic pain among young adults, especially university-attending adults has emerged in our study as a further focus for PTSD treatment. Future research would benefit from embedding assessments of pain that capture more precise duration and location, and potential PTSD related triggers of variations in pain experience.

Mindfulness

Significant increases in three of the five mindfulness facets after eight weeks of intervention were observed in this study, which partially supported our hypotheses. Improvements in *non-judging* ($d = 0.96$), *non-reactivity* ($d = 0.83$) and *acting with awareness (d* = 0.64) FFMQ facets were reported. Foundational to mindfulness and yoga is the insight of impermanence and its utility in reappraising distressing events (Gard et al., 2014). For instance, awareness of change may facilitate neutral *judgments* (neither good nor bad) of transient phenomena (memories and feelings) and promote a *non-reactive* stance to their distressing qualities (Davis et al., 2019). In turn, one may begin to *act with awareness* and *observe* without aversion or avoidance, which may then lead to the integration of trauma (Davis et al., 2019).

The lack of FFMQ-Observing and Describing improvements may be explained by the potential interaction with hyperarousal symptoms (Kalill et al., 2014). This view is supported by research suggesting that articulating and communicating emotions becomes easier when

amygdala hyperactivity is reduced (Lieberman et al., 2007), given that such hyperactivity is a frequent neuro-correlate of PTSD (Williamson et al., 2015). Combining these findings with the minimal changes in parasympathetic function observed in HRV indices suggest that improvements in FFMQ *observing* and *describing* may occur at a later stage in the trajectory of PTSD recovery. Another plausible explanation is the consideration of the role dissociation plays as a dysfunctional coping strategy negatively associated with mindfulness (Escudero-Pérez et al., 2016). All but one participant in this study disclosed clinical symptoms of dissociation (e.g., depersonalization) which have important implications for both psychometric and psychophysiological findings. Dissociation is associated with the suppression of thoughts and memories related to extreme trauma, manifested through avoidance and numbing (Kratzer et al., 2018). Dissociation is prevalent in individuals with repeated trauma exposures and is particularly prominent in survivors of childhood abuse (Kratzer et al., 2018). Dissociation is a process of compartmentalization of psychological functioning and can present as marked difficulty in labeling emotions and also in feeling easily overwhelmed by emotional triggers (Kratzer et al., 2018). Mindfulness practices attempt to *integrate* one's experience through non-judgmental present moment awareness and often serves as a helpful tool in attenuating maladaptive dissociative reactions (Kabat-Zinn, 2003a; 2003b; van der Kolk, 2015; Zerubavel & Messman-Moore, 2015). It is possible that eight weeks of a CBT-MY intervention was not long enough to yield significant improvements in FFMQ-Observing and Describing given the chronicity of childhood trauma exposure and subsequent dissociative experiences found in our sample. Future research investigating longitudinal changes in dissociative symptoms and FFMQ facets across a longer intervention period (e.g., 16-24 weeks) is necessary. Nevertheless, the improved outcomes in mindfulness lend support to the benefit of including online CBT-MY interventions in the treatment of PTSD.

Psychophysiological Outcomes

In terms of psychophysiology measures, there were large effect size reductions for PPD (d = 0.90) contrasted with insignificant HRV effects (p = .87). Post-intervention PPD and PTSD symptom outcomes (CAPS 5, PCL-5) were correlated (p = .05), suggesting an association between self-report and PPD measures indicative of improved autonomic balance. HRV measures, however, were unaffected by intervention effects and were not associated with PTSD outcome variables.

Heart Rate Variability

When compared to non-PTSD participants, PTSD-affected participants had a significantly lower HF HRV at both pre- and post-intervention across all phases of the 25-minute protocol. Furthermore, when compared to non-PTSD participants, PTSD participants had a significantly higher baseline resting heart rate (HR) at baseline and post-intervention ($p < .05$). These findings are congruent with prior research examining the impact of trauma exposure and PTSD on autonomic dysregulation (HR and HF HRV; Cohen et al., 1997; Dennis et al., 2014). Autonomic rigidity, evidenced by low HF HRV, is a frequent PTSD finding indicative of reduced capacities to modulate physiological and emotional responses to environmental changes (Thayer et al., 2009; Thome et al., 2017). Our Non-PTSD participants were able to significantly increase their HF HRV during the onset (0-5mins) of the emotional stress task compared to baseline resting states, suggesting a superior ability to self-regulate and mobilize parasympathetic activity during negative image exposures (Shaffer & Ginsberg, 2017). In contrast, there were no significant changes in HF HRV in PTSD participants from baseline to emotional stress phases at baseline or post-intervention, which did not support our hypotheses.

Comorbid Depression and HRV

PTSD is often associated with comorbidities characterized by persistent negative cognitions and mood related to the low and invariant HRV observed in our study (Vaccarino et al., 2008). It is possible that the repetitive trauma exposures of relatively long duration found in study subjects were unresponsive to eight weeks of intervention. Eight weeks appears insufficient for achieving stable improvement in stimulation of the parasympathetic subsystem of cardiac function, especially in populations with chronic pediatric exposures, given the consequential deficits in social, emotional and physiological development (Agorastos et al., 2019; van der Kolk, 2017). It is possible that the severity of depression at baseline had a blunting effect on HRV found during the 25-minute protocol and reduced pre-post intervention-related change. A non-responsive HRV to intervention is supported by existing meta-analytic findings on associations between major depressive disorder and diminished HF HRV (Koenig et al., 2016; Kemp et al., 2010). Although the additional compound effect of chronic childhood trauma exposure and multiple or repeated trauma exposures were not primary focuses in these meta-analytic reviews, these kinds of exposures, observed in this study, may have strengthened the relationship between comorbid depression and PTSD. Research conducted by Stone et al. (2018) examining the link between childhood emotional abuse and HF HRV, among women, indicated that depressed women with histories of childhood emotional abuse exhibited significant decrements in HF HRV when compared to depressed women who reported no childhood emotional abuse (d = 0.90) and controls (d = 0.87). This finding remained stable even after controlling for respiratory and health-related factors (Stone et al., 2018). These findings suggest that childhood emotional abuse is a strong predictor of impaired parasympathetic control reflected in low and non-intervention responsive HF HRV that extends into adulthood and may explain the non-significant HF HRV changes in our study. The gold standard PTSD assessments

(e.g., CAPS-5, PCL-5) used in this study did not adequately capture childhood trauma exposure, frequency and duration, and largely emphasize a single-index trauma exposure to guide assessment. Future clinical trials would benefit from incorporating additional assessments of childhood trauma exposure, particularly emotional abuse, and repeated/multiple trauma exposures in standard intake protocols to establish clear correlates of PTSD symptom severity. In addition, the low and treatment-resistant HF HRV found in our study is a well-known biomarker of psychopathology that may be best explained by the compound effect of comorbid depression and chronicity of childhood trauma exposure reported and warrants further clinical investigation.

Peak Pupil Dilation

While reductions in peak pupil dilation across the 25-minute protocol supported our hypotheses, the question remains as to why significant reductions were observed in PPD but not HRV? One explanation involves the mechanisms unique to ocular versus cardiac functioning. Theoretically, peak PPD measures reflect a more immediate reaction to threat stimuli than HRV, as PPD responses appear to precede the autonomic reactions assessed by HRV (Appelhans & Luecken, 2006; Mckinnon et al., 2020; Thayer et al., 2009). While HRV changes apparently reflect autonomic responses heavily influenced by cognitive-emotive responses, PPD changes appear to reflect reductions in unconscious or pre-cognitive hyper-vigilance, hypothesized as prevalent in PTSD (Appelhans & Luecken, 2006; Mckinnon et al., 2020; Thayer et al., 2009). The varying foci of PPD and HRV measurement also significantly differed. PPD, representing autonomic function, was measured within the first 300-500 ms of the onset of an image stimulus. This represents a significant duration difference when compared to the recommended HRV measurement of 5 min epochs (TFESC, 1996). Not only does this indicate PPD and HRV measurement differences were, retrospectively, predictable because the observation period

differed, but it suggests the physiological response of subjects differed significantly *during* image exposure. In the PPD response, participants were apparently less reactive to images at post-intervention than at baseline, while HRV remained invariant and indicated sustained autonomic dysregulation post-intervention. Theoretically, the *ability* to *sustain* a less threatened response via HRV is unlikely because participants are highly vulnerable to the more habit-based cognitive rumination and/or catastrophizing responses that 'kick in' after an initially less disturbed image response (Beauchaine & Thayer, 2015). Prior research has indicated an indirect relationship between HRV and PPD with low HRV linked with perseverative cognition symptoms (Ottaviani et al., 2009; Woody et al., 2014), shown to be linked with greater pupil dilation to negative stimuli (Duque et al., 2014; Siegle et al., 2003).

Few studies have explored direct associations between HRV and associated pupil response during rest, stress-induced and meditation phases in clinical samples. Our findings are supported by a recent study by Macatee et al. (2017) that examined emotional processing indications of pupillary response and HRV in a non-clinical sample responding to positive, negative and neutral stimuli. The authors found, notably, that HRV was unrelated to negative emotional processing and was not significantly associated with pupillary indices of negative stimuli (Macatee et al., 2017). In contrast, low HRV predicted decreased pupil dilation to *positive* stimuli after a stress phase, reflecting altered *positive* emotional processing following stress induction (Macatee et al., 2017). As our study did not include positive emotional stimuli, direct comparison is not possible. Future replication of our study with the inclusion of positive emotional stimuli may provide important clues of emotional processing among adults with PTSD via HRV and PPD and their associations. The observed null response in HRV amidst significant PPD reductions may suggest alternative neural mechanisms underlying the psychopathological

response patterns found in our study. Further clinical research is required to explore these potentially important differences in response patterns.

Presence of Habituation

The repeated presentation of negative emotional images during the 25-minute lab protocol raises the potential for habituation and sensitization effects. Habituation is a well-documented behavioural response which causes either decreased or increased response to repeated stimulation (Groves & Thompson, 1970). Participants in our study were required to view 60 negatively valent emotional images one at a time for 10-minutes, before and after the intervention in a consistent order. Confounding factors may have included the use of negative-only images, the selection of mildly (instead of extremely) unpleasant images (to ensure protocol safety) and the use of colour images of varying complexity (e.g., proximal photo of a gun vs. a graveyard scene). In human participants viewing emotional images, predictable responses (e.g., skin conductance responses, facial muscle changes, heart rate variability) occur depending on the emotion, novelty and intensity of images (Bradley et al., 1993). Research conducted by Bradley et al. (1993) examining startle reflex habituation (e.g., eye blinks) patterns, along with habituation patterns of facial response, heart rate, and skin conductance, indicated that all response mechanisms showed predictable differentiations between positive, neutral, and negative picture content *and* a general habituation response over trials. In this study, the unique response of the startle reflex is notable, as it is measured from the orbicularis oculi muscle of the eye, which continued to differentiate among affective picture contents, *without* habituation effects, suggesting a neural mechanism that differs significantly from cardiac responses (Bradley et al., 1993). The results revealed that eye blinks were significantly augmented in magnitude, as measured by electromyography (EMG), during presentation of negative emotional images

compared to pleasant images ($F(1,17) = 11.23$, $p < .05$; Bradley et al., 1993). When compared to neutral images, the startle reflex was significantly larger in unpleasant images and significantly inhibited during pleasant images ($p < .05$; Bradley et al., 1993) with differences that remained stable across repeated trials. These findings are supported by animal research (Davis et al., 1988; Davis, 1990) where findings suggest two neural circuits contribute to the overall magnitude of the excitatory (i.e., startle reflex) autonomic response: a *primary, obligatory* circuit (e.g., heart rate, skin conductance) and a *secondary, modulatory* (e.g., eye blinks, pupil response) circuit. The *primary* circuit operates predominantly within the spinal cord and the *secondary* circuit is based on sensory processing on the reticular site of the central nucleus of the amygdala (Davis et al., 1988; Davis, 1990). The secondary circuit has been shown to augment and sustain startle reflexes through fear-conditioned stimuli in animals (Davis et al. 1988) and humans (Bradley et al., 1993). The findings from Bradley et al. (2003) must be interpreted with caution given this reference study's modest sample size ($n = 22$), moderate affective intensity of image stimuli used, lack of direct pupillary measurement, and cross-sectional nature of the study. However, the lack of a secondary circuit habituation found in the study conducted by Bradley et al. (1993) suggest that pupil response is resistant to habituation and was unlikely in our study.

Another study conducted by Schupp et al. (2006) examined the effects of stimulus repetition on emotional processing in the visual cortex in a protocol where participants were instructed to passively view erotic, unpleasant, and neutral control images while connected to an electroencephalogram (EEG). Overall, there were 40 images presented, one at a time every 330ms, repeated 90 times in different orders for a total of 3600 picture presentations per subject (Schupp et al., 2006). Findings revealed a significant main effect of emotional valence in the temporo-occipital and fronto-central brain regions with the most pronounced stimulus reaction occurring within 200-300ms of image onset. Compared to neutral images, negative and arousing

stimuli produced significantly more reactivity within the brain although no significant interaction between repeat stimulus exposure and affect ($p > .05$) was found (Schupp et al., 2006). This suggests that the detection of emotionally provoking stimuli (e.g., threatening, arousing) is minimally subject to habituation within visual cortex brain regions. In contrast, autonomic responses like heart rate and skin conductance have been found to rapidly habituate after stimulus repetition indicating a varied processing of emotionally valent information (Bradley et al., 1993; Codispoti et al., 2006; Öhman et al., 1974).

In a recent study by Snowden et al. (2016), pupil response habituation to affective images was examined using four blocks of 20 image presentations (10 fear, 10 neutral) presented randomly. The authors carefully controlled images with respect to luminance (e.g., brightness), colour (e.g., greyscale) and complexity, given these factors are known to influence pupil response (Snowden et al., 2016). The authors examined pupil response in the first 300ms, similar to our study, where no saccades (e.g., random ballistic eye movements, gaze interruptions) could be initiated that could potentially confound results (e.g., Snowden et al., 2016). The results revealed no sign of habituation across any of the blocks of image presentations ($p > .05$). In our study, luminance was controlled on the computer screen and in the lab room where the experiment was conducted (e.g., dimly lit computer screen, blacked out window, and room lux set at 71). The images in our study were not controlled for colour or complexity, nor was a blank screen implemented before or after image presentation to return the pupil to baseline, which is in contrast to Snowden et al. (2016). Our study aimed to examine pupil response under more natural environmental conditions where repetitive exposures to colour images were conducted without interruption. While several studies indicate that pupil responses are resistant to habituation, continued research comparisons of threatening stimuli in more "real-life" contexts (using streaming of colour images and video content) with laboratory-controlled

experiments would help further clarify the extent of habituation each of these contexts. Based on prior research, we do not expect habituation to be a plausible reason for the significant reductions in PPD found in our study.

Given the studies described above, a number of critical questions in our study are worthy of further consideration. First, were the negative emotional images selected sufficiently evocative to elicit an autonomic stress response during the stress phase of the protocol? Based on comparisons with non-PTSD participants, there were no significant between-group differences in PPD during the emotional image stress phase which suggest the emotional stimuli selected were not sufficiently evocative to produce an expected stress response. Our findings contrast with similar research conducted by Cascardi et al. (2015) that indicated that individuals who met PTSD diagnostic criteria showed large effect size differences ($d = 0.75$) in pupil dilation to threatening stimuli compared to trauma-exposed controls without PTSD ($p < .01$). The threatening images used in Cascardi et al (2015) had an IAPS arousal rating of greater than six (Lang et al., 1997). The mean arousal rating of the images in our study was 5.51 and only 17 (28%) of the images selected had an arousal rating greater than six. Our preference for milder images, due to concern for the welfare of traumatized subjects, may explain the non-significant differences with the convenience sample of non-PTSD participants (See Appendix E). Additionally, participants in our study did not rate their perceived level of threat per image, which, in retrospect, may have produced data helpful in discerning subjectively perceived threat levels. Future replication studies that combine objective pupil response with subjectively reported experience are planned and recommended (Cascardi et al., 2015).

Another critical question is, the extent to which the addition of positive stimuli might identify additional relationships between HRV and pupil response? In a recent cross-sectional study that examined pupil response to negative *and* positive images in PTSD diagnosed

individuals, McKinnon et al. (2020) found significantly larger pupil dilation to both threatening and positive (happy) images among individuals with PTSD compared to trauma-exposed controls with no diagnosed PTSD (threatening $d = 0.87$; happy $d = 0.73$), and controls with no trauma exposure (threatening $d = 0.85$; happy $d = 0.97$). These findings suggest autonomic function in PTSD is sensitive to *both* negative and positive image stimuli. Future studies of autonomic response to various emotional stimuli would inform the use of pupillometry as a PTSD biomarker. In McKinnon et al. (2020), a shorter image presentation (2000ms) was used than in our study (10 s) and each image was preceded and followed by a grey screen with a neutral fixation cross to allow the pupil to return to baseline. Additional variations in equipment used and analysis procedures make precise comparisons difficult with our findings, however, the results from McKinnon et al. (2020) combined with our study findings lend support to the continued use of pupillometry in the assessment of emotional dysregulation and treatment of PTSD.

Additional questions include: 1) whether the introduction of fixation crosses during guided meditation introduced a confounding distraction variable (e.g., cognitive viewing task) that limited observations of a true relaxation response, and 2) to what extent did colour exposure and image complexity (e.g., scenic vs. facial) influence pupil response? Understanding pupil response in relation to PTSD psychopathology and emotional processing remains largely unexplored and requires further study in longer-term, randomized controlled studies with comparisons to non-clinical populations. Ultimately, more research is needed to evaluate more hypotheses related to adults with diagnosed PTSD responding predictably to emotional stimuli. Despite these questions, our study contributes evidence to the literature exploring pupillometry as a marker of PTSD psychopathology. Our findings indicate that adults with PTSD have unique neurophysiological responses when compared to a convenience sample of non-PTSD

participants, and reflect responsiveness to an online CBT-MY intervention, manifested in indices of reduced PPD.

Dose-Response Effects

Our sample of participants reported spending a mean of 12-mins/day in self-directed mindfulness-based practice, which may have been sufficient to alter PPD patterns and influence pre-cognitive autonomic function. Twelve minutes per day, however, is apparently insufficient for changes in autonomic regulation measured by HRV after eight weeks. Prior controlled trials examining the effects of mindfulness autonomic function have found significantly higher gray matter concentration in the left hippocampal region of the brain in healthy meditators that spent 27-minutes/day in mindfulness (Holzel et al., 2011) and changes in connectivity of white matter fibers adjacent to the thalamus among long-term meditators (> 15-years; Laneri et al., 2016). The thalamus relays immediate sensory information (as implicated in pupil dilation) and the hippocampal region is involved in the modulation of cortical arousal and emotional responsiveness (Holzel et al., 2011; Laneri et al., 2016). Unfortunately, neither of the referenced studies involved PPD measurement. Nonetheless, the reductions in PPD in our study, although combined with invariant HRV, provide partial support of our hypothesized changes in autonomic function after 8-weeks of CBT-MY intervention. Given the toxic effects of PTSD psychopathology on select brain regions (e.g., decreased density of hippocampus), the lack of HRV improvement is possibly explained by such effects (Holzel et al., 2011). Achieving states of safety, autonomic regulation, and relaxation are challenging for traumatized individuals and recovery rates vary in association with baseline severity of PTSD symptoms, comorbidities, duration of trauma exposure, and time since last trauma exposure (Galovski et al., 2012; Price et al., 2017; van der Kolk, 2017).

Of particular importance was the significant post-intervention change in PPD in the first 5-min of guided meditation, while there were no indications of sustained PPD change in the last 5-minutes of meditation. While participants reported a mean of 12 min/day in mindfulness, this was not always accumulated in one sitting. Indeed, the prescription of mindfulness in this CBT-MY program encouraged smaller, more frequent doses of mindfulness in bouts of 90 sec or more, following considerations that many subjects were being newly introduced to the practice of mindfulness, amidst significant academic and work demands, and PTSD symptom severity. In mindfulness-based research, many studies are based on standardized programs like MBSR (Kabat-Zinn, 1982) that consist of eight 120-minute weekly group sessions, a full-day retreat, and daily homework of 40-60min (Kabat-Zinn, 1982). For young adults in post-secondary education, especially those with difficult symptoms of PTSD, the MBSR framework would likely be too time-consuming and vulnerable to higher attrition rates (Dobkin et al., 2012). In a recent meta-regression of 15 971 non-clinical participants across 203 RCTs conducted by Strohmaier (2020) that examined the relationship between doses of mindfulness and depression, anxiety and stress, the findings showed that the dosage of mindfulness is moderated by mental health condition. Meta-regression results revealed a significant dose-response relationship between recommended duration of self-guided practice and depression (d = 0.01) and stress (d = 0.82). When compared with inactive controls, the results revealed prescriptions beyond a certain duration of self-guided mindfulness predicted *increased* depression and levels of stress among participants (Stohmaier, 2020). In contrast, Strohmaier (2020) found a large effect dose-response relationship between prescribed mindfulness and anxiety (d = -1.63) suggesting that increased duration of mindfulness was linked to reductions in anxiety although not in depression. While the magnitude of effect was small for depression, but large for stress, the contrasting findings between anxiety and depression point to the need to tailor suggestions for self-guided practice to

the unique characteristics of the clinical population under investigation. In terms of program intensity (e.g., duration, inclusion of full-day retreat), greater mindfulness intensity predicted decreased mindfulness compared with active controls, and no evidence was found that larger doses of mindfulness were more helpful than smaller doses for mental health outcomes, which is particularly relevant for the population studied in this dissertation (Strohmaier, 2020). All of these findings, notably, were based on self-report measures of practice and program prescriptions, and therefore vulnerable to social desirability reporting confounds. Increased intensity and prescription of mindfulness may be a deterrent for young adults with PTSD, particularly with exacerbated negative cognition and mood symptoms including negative self-concept and exaggerated self-blame as a result of trauma exposure. The importance of carefully selecting a dosage of mindfulness that is less intense (e.g., 90-sec to 5-min bouts) than traditional MBSR program may be more beneficial for populations with PTSD to help build self-efficacy and confidence, which in turn may translate to program adherence and completion. The findings from Strohmaier (2020) highlight an important component for future clinical intervention surrounding the optimal dosage of mindfulness practice. Once again, there are needs for cautious interpretations given the small sample sizes, the ambiguity surrounding whether measures were based on self-report or prescription, variety of non-clinical populations studied and heterogeneity among RCTs examined. Replication of RCTs examining dose-response relationships between mindfulness and clinical PTSD are worthy of future consideration.

Although we covaried for multiple health factors in our research, our models did not account for the influence of pharmacotherapy on PPD and HRV outcomes given the varied types and dosages of prescriptions in participants, and was beyond the scope of this investigation. Evidence suggests that diagnosed psychiatric patients treated with tricyclic antidepressants demonstrate decreased HRV (Gorman & Sloan, 2000). Tricyclic antidepressant medications

contain anticholinergic compounds observed to reduce HRV which may explain non-significant HRV findings in our study (Gorman & Sloan, 2000). Selective serotonin reuptake inhibitors (SSRIs), another medication used to treat depression, has been less influential on HRV. Although SSRIs appear to decrease LF HRV in patients diagnosed with a panic disorder, the relationship with HF HRV measurement is less clear (Gorman & Sloan, 2000). Pharmacotherapy effects on PPD are less clear and less studied. Nonetheless, the significant reductions in PPD found in this study appear to reflect positive intervention responses. With positive changes in PPD, the PTSD survivor could experience environments as less dangerous, and perceive potential threats as less severe and in a more normative range. Over time, such changes might be accompanied by positive responses in autonomic balance reflected, for example, in HRV indices. Future RCT studies examining longer intervention periods and follow-up measures would perhaps ascertain a more ideal amount of self-directed learning to increase HRV. In this 8-week CBT-MY intervention study, the effects appear sufficient to reduce hyper-vigilance, while not yet sufficient to impact the later autonomic responding reflected in HRV.

Study Strengths and Limitations

Strengths of this study include the rigorous clinical PTSD screening and assessment. The CAPS-5, a clinician-administered structured interview, is labour-intensive but is intended to be flexible and precise (Weathers et al., 2001). In addition, the PCL-5, a self-rated PTSD assessment, was additionally used to precisely define and measure PTSD in conjunction with objective markers of autonomic function. Autonomic function of participants with PTSD and direct comparisons with a convenience cohort of non-PTSD affected, relatively normative participants, were also conducted to assess psychophysiological differences.

One of the main limitations of this study was the risk of experimenter bias in relation to the PTSD assessments since the CAPS-5 interview at pre- and post-intervention was conducted by the intervenor. The lack of blinded assessment limits the validity of findings. A review process was initiated where a second clinician with no relation to the study examined and verified all CAPS-5 notes and scoring. Ideally, future RCTs, with randomization procedures and assessor blinding, can further reduce experimenter biases and are recommended.

Study findings must also be interpreted within the context of other study limitations. First, the sampling frame was limited to a single, large academic institution (> 50 000 students) and may not be reflective of the entire young adult PTSD population, particularly those who do not attend post-secondary institutions and are from lower SES environments. In addition, we did not include those that have graduated, or dropped out, and are now working. Although the sample obtained was relatively representative of a diverse, multicultural student population, the participant reach is unknown, and a participant response rate could not be determined. Accordingly, those who met inclusion criteria, but declined to participate, or did not inquire about the study represent an important, understudied population. Factors such as heavy school demands, academic and work pressures, and length of the clinical trial may have reduced recruitment and limited generalizability.

Second, the motivations to participate in the study may have introduced potential biases. A specific threshold of PTSD symptom severity was required to enroll in the study which may have led to social desirability bias whereby participants provide responses that ensured their qualification, instead of responses that reflected their true feelings (Grimm, 2010). As a remedy, the interviewer underwent specialized training in order to accurately assess participant responses to the CAPS-5 to enhance the validity of responses. Additional measures to eliminate the potential for bias included having an external trained CAPS-5 interviewer who additionally

examined and assessed responses to the CAPS-5. As well, the use of a secondary validated PTSD survey, that did not require the presence of an interviewer, was implemented to verify accuracy and reduce social desirability bias (Grimm, 2010). The addition of objective markers of PTSD, as confirmatory assessment tools, also addressed social desirability bias and is relevant in future clinical research.

As noted, the original clinical trial design included a second trained clinician to conduct the post-intervention CAPS-5 assessment. Despite the efforts to reduce experimenter bias, an unforeseen and unexpected phenomenon occurred whereby participants would not show up or reply to appointment requests when told that a second interviewer, with no intervention relationship to the study, would conduct the follow-up CAPS-5 interview. A plausible explanation for the resistance to follow-up could be the sensitive and exposing nature of the CAPS-5 interview where participants are required to disclose and recall past traumatic exposures. Therapeutic alliance can significantly influence clinical outcomes, especially in the presence of childhood abuse (Cloitre et al., 2004). Having to divulge this confidential information to someone new may have been potentially triggering for participants who had worked closely with the original interviewer/coach throughout the entire duration of the study. Thus, the decision to have the follow-up CAPS-5 interview conducted by the same interviewer/intervenor was made to ensure follow-up measures were not missed. We acknowledge the limitations this has on the validity of the follow-up results given the lack of a blinded assessor; however, we felt the priority was to maintain client-centered care of confidentiality, safety, and therapeutic alliance to ensure follow-up measures were collected.

Third, the single-arm experimental design that included comparisons with a convenience sample of non-PTSD participants, and no assessor blinding, prevents us from determining causal relationships. In addition, the Non-PTSD sample was recruited from the Psychology

Undergraduate Research Participant Pool where students receive academic bonus marks for participation. The Non-PTSD participants only had to self-report no PTSD and did not complete a full mental health assessment. Thus, it was impossible to label this group as a true normative group, which limits the comparisons made. Despite design limitations, single-arm experimental studies provide a foundation for future causation assessment. The findings from this trial provide preliminary evidence that online CBT-MY programs for PTSD recovery influence subjective *and* objective symptom recovery. Future longitudinal studies using an RCT design with direct comparisons with a non-clinical, normative group would help better validate causal pathways to symptom improvement.

In summary, the treatment of PTSD is a public health priority given the rise in number of people coming forward with stories of trauma and the collective trauma experienced by the current COVID-19 global pandemic. Identifying effective treatment factors advances the most opportune clinical treatment strategies that may serve to address the growing demands for mental health care. This study provided evidence that self-reported PTSD symptom severity significantly declined after an eight-week online CBT-MY intervention. Those with comorbid conditions of depression and anxiety, increased mental health conditions and medications, had greater difficulties with symptom reduction pointing to the need for targeted approaches. In addition, this study supports the utility of using pupillometry and HRV to further explain and predict PTSD symptom recovery. Pupillometry appears to be a cost-effective and accessible outcome measure of PTSD and method to track treatment progress.

The attrition rate of the single-arm experimental trial was 18.2% with four PTSD participants not completing the post-intervention follow-up measures, which limits a full understanding of the intervention effect. Two participants withdrew at week 2 and week 7 with self-reported child-care obligations (week 2) and current trauma/stress exposure (week 7) as

reasons. The remaining two participants were lost to follow-up without any reason being reported. Based on CAPS-5 outcomes, the four participants who withdrew had significantly higher symptom severity for *Criterion D*: *Negative Cognition and Mood Symptoms* suggesting that the intervention may be best implemented as an adjunctive treatment in combination with clinical psychological treatment addressing disturbed mood, or as a stand-alone program after acute mood symptoms and cognitions have been adequately addressed. Other considerations such as time barriers and work or parenthood demands may be key factors to consider for future RCTs.

In addition to our sample being small, participants were mostly Caucasian, female, and highly educated. However, these data provide a unique departure from the focus on war veterans in existing PTSD research. Other clear limitations include the lack of a randomly allocated wait-list control group, measurement blinding and the absence of assessment of long-term changes or maintenance.

From an intervention perspective, online clinical treatment of PTSD using a combination of CBT therapy with a trained coach/therapist, and online self-directed mindfulness and yoga practice appears potentially useful as an adjunctive treatment to standardized one-on-one clinical care. The heterogeneous findings from this study reveal that a focus on broad-based clinical treatment efforts aimed at PTSD symptom management to ameliorate the effects of a wide range of trauma exposures be a priority for future investigation, rather than the development of precise treatment approaches for individual outcomes. Thus, our findings support the recent evidence-based online CBT-M intervention conducted by Ritvo et al., (2021) for youth with depression and varying exposures to trauma, a clinical trial that potentially addresses the gaps based on 1) lengthy wait-times and geographical barriers to accessing clinical treatment and 2) tailors to young adult preferences for self-directed mindfulness and exercise in conjunction with weekly

counselling. Sensitive effects of trauma exposure including less widely considered exposures (e.g., racialized trauma, intergenerational trauma), time of first exposure, and duration are a priority for future research to better ascertain which population is at the greatest need for PTSD intervention.

Conclusion

The purpose of this study was to evaluate the effectiveness of an 8-week online CBT-MY program with online therapist support among a previously understudied young adult population with current PTSD. The results of this clinical trial suggest that the lived experience of trauma is far more complex and prevalent than previously been reported in a Canadian national epidemiological study (Van Ameringen et al., 2008). Future RCTs that examine whether the present findings extend to larger and more diverse samples, and whether similar gains are achieved are maintained after treatment are necessary. We are left with the challenging question of whether undertreated PTSD populations may be treated more effectively with only CBT-MY treatment, and other accessible delivery methods that reduce the socio-economic and human costs of PTSD. The findings of this study are encouraging but require more intensive and carefully controlled study.

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Appendices

Appendix A: Systematic Review and Meta-Analysis of Online CBT Interventions

Effectiveness of Online Cognitive Behavioral Interventions that Include Mindfulness for Clinically-Diagnosed Anxiety and Depressive Disorders:

A Systematic Review & Meta-Analysis

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Abstract

Background: Online cognitive behavioral interventions that include mindfulness have attracted attention, given the demonstrated benefits of mindfulness and scalable opportunities for increased use without significantly increased costs. However, comparatively little is known about the effectiveness of these types of interventions when they are delivered to clinician-diagnosed populations receiving psychiatric treatment. **Aims:** This review evaluates therapeutic interventions that included a mindfulness component aimed at reducing anxiety and depression in clinician-diagnosed samples. **Methods:** Randomized control trials (RCTs) published between January 1990 to September 2020 assessing the effects of online cognitive behavioral interventions that include a mindfulness component were searched across five databases (Medline, PsychINFO, PubMed, CINAHL, Web of Science). **Results:** Eleven studies met inclusion criteria with sample sizes ranging from 37 to 84 per study. Findings revealed an overall significant moderate effect for reductions of depression (Cohen's d = -0.47) and anxiety (Cohen's d = -0.40) symptoms among online treatment groups. Further analyses revealed the observed reductions were above the minimal clinically important difference (MCID) for BDI-II. **Conclusions:** Findings from this meta-analytic review provide preliminary support of building mindfulness into existing therapeutic programs to reduce depressive symptoms in clinician-diagnosed populations. Research implications and priorities for online mindfulness-based cognitive behavioral programming are discussed.

Keywords: Mindfulness; Psychotherapy; Internet; Mental Health; Depression; Anxiety

Introduction and Background

Diagnosed mental health conditions, most commonly anxiety and depression, are characterized by deficits in cognitive-emotional processing, social functioning (WHO, 2016), physical comorbidity risks (e.g., cardiovascular disease; De Hert et al., 2009; Sokal et al., 2004). Mental health disorders represent an economic burden (~$2.5 trillion in 2010) likely to increase exponentially to $6 trillion by 2030 making *diagnosed* psychiatric disorders the most costly non-communicable condition (Bloom et al., 2011; Whiteford et al., 2013; World Health Organization, 2008). Beyond treatment, costs also extend to lost employment, reduced productivity, chronic disability, and premature mortality (Smetanin et al., 2011; Whiteford et al., 2013; World Health Organization, 2008). According to the World Health Organization (2016), depression is the leading contributor of disability worldwide with ~350 million adults affected annually. Nearly the same number of adults experience anxiety disorders with many experiencing both depression and anxiety concurrently (WHO, 2016). Unfortunately, only estimated >20 % of adults carry a *current* psychiatric diagnosis or receive appropriate treatment (e.g., pharmacotherapy, psychotherapy) for a mental health disorder (CDCP, 2011; Medco Health Solutions Inc, 2011; Smetanin et al., 2011) leaving a substantial proportion of the global population undertreated.

Although traditional (e.g. pharmacotherapy, face-to-face psychotherapy) and newer therapies (e.g. Transcranial Magnetic Stimulation) have shown to reduce difficult mental health symptoms (Berlim et al., 2014; Cuijpers, Berking, et al., 2013; Cuijpers, Sijbrandij, et al., 2013), access to treatment is hindered by perceived stigma or embarrassment of disclosure, growing waitlists, limited availability of trained therapists, financial and geographical barriers resulting in a fraction of those needing treatment receiving treatment (Gulliver et al., 2010; Hudson, 2012). Given a growing treatment gap, there is an urgent need to understand the effectiveness of treatment approaches targeting these barriers such as scalable, technologically assisted, online

treatments. Indeed, online delivery of cognitive behavioral therapy (CBT), an evidence-based treatment approach for depression, has shown potential to reduce costs, address accessibility challenges while also minimizing stigma by empowering the individual to self-direct their learning in between therapy sessions. Despite this promise, however, treatment uptake and program adherence remain impeded warranting further investigation of the effectiveness of adjunctive, hybrid treatment components with standard psychotherapy.

One emerging treatment modality for anxiety and depression that is proven effective, low-cost, and accessible is the addition of mindfulness meditation in conjunction with established psychotherapy approaches. Integrated health modalities such as mindfulness meditation are easily taught in an online platform and can be self-administered as needed to help empower patients to become active participants in their own self-management of symptoms, presenting a cost-effective adjunctive method to maintain the benefits received from traditional psychotherapy. Mindfulness meditation trains individuals in moment-to-moment focal attention and non-judgmental awareness of cognitions and somatic sensations (Bishop & Bishop, 2004; Jon Kabat-Zinn, 2003; Lutz et al., 2008)that occur daily. Adopting a self-guided mindfulness practice as a stand-alone practice or as part of a therapeutic framework has shown to be helpful in managing acute symptoms related to anxiety and depression and offers an immediate therapeutic tool to implement when difficult symptoms or emotions surface. Face-to-face stand-alone mindfulness-based interventions (e.g. mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1982), mindfulness-based cognitive therapy (MBCT; Segal et al., 2012), and acceptance-commitment therapy (ACT; Hayes et al., 2012) are empirically supported treatments that use mindfulness for reducing anxiety symptoms, preventing depressive relapse, and enhancing emotional regulation in non-clinical (Chiesa & Serretti, 2009; Fjorback et al., 2011; Gotink et al., 2015) and clinical populations (e.g., cancer, depression, anxiety; A-Tjak et al., 2015; Cramer et

al., 2012; Gotink et al., 2015; Hofmann et al., 2010; Sipe et al., 2012). Meta-analytic reviews of established internet-based cognitive behavioural interventions (e.g., CBT, ACT) in reducing depression and anxiety indicate online deliveries have nearly equal effects to traditional in-person approaches (Andersson et al., 2011; Andersson & Cuijpers, 2009). Internet-based treatment alternatives were further supported in a recent meta-analysis on self-guided internet-based CBT programs as a *first line* therapy in reducing depressive symptoms (Karyotaki et al. 2017). What remains unclear is whether online interventions that combine mindfulness meditation with internet-based cognitive behavioral psychotherapies like CBT or ACT have the potential to yield even greater results in symptom reductions among clinician-diagnosed populations. Current meta-analytic reviews of online mindfulness-based cognitive behavioral interventions explore outcomes for *general* populations that self-report anxiety or depression and show relatively similar effects to online stand-alone CBT and face-to-face mindfulness (Cavanagh et al., 2014; Fish et al., 2016; Spijkerman et al., 2016). Unfortunately, these reviews limit our understanding of the *clinical relevance* of treatment effects given the blend of non-clinical and clinically-diagnosed populations (Spijkerman et al., 2016), significant heterogeneity in treatment delivery format (e.g., hard-copy materials vs. stand-alone online delivery; Cavanagh et al., 2014), and varied treatment methodologies employed (Fish et al., 2016). While these authors have made significant contributions to the understanding of online therapeutic interventions that use mindfulness components, there is a need for focused research on the utility of blended (e.g., CBT + mindfulness) treatment interventions for clinician-diagnosed populations to help refine diagnostic treatment options and provision of treatment to improve patient-specific outcomes.

Prior reviews that have blended together participants with self-reported depression and anxiety symptoms *and* samples with clinician-diagnosed depression and anxiety disorders

present a significant methodological limitation as there are key, unique differences in self-reported versus clinician-diagnosed mental health disorders (Spijkerman et al., 2016). Given the emergence of online treatment approaches, clinician-diagnosed populations are a priority since they provide unique information specifically relevant to the clinical diagnosis, prognosis, and treatment outcomes that self-report measures may not capture. Individuals who have received a clinician-diagnosis may also yield unique treatment results from self-reported general populations since they have endured the process of obtaining a clinical diagnosis and may be more active treatment-seekers as a result of having a clinical diagnosis. For example, given exposures to the clinical diagnosis process, these individuals may confront a diagnosed disorder in a manner that is medically equivalent to other diagnosed chronic diseases such as diabetes, and be more willing and ready to adopt additional changes in health behaviour in between treatment sessions (e.g., exercise, mindfulness). Furthermore, this subgroup has a greater likelihood of being exposed to single or multiple psychiatric medications (e.g., SSRIs, anti-anxiety medication) which may result in treatment plateaus which may potentially be addressed with access to multi-modal online intervention approaches above and beyond standard clinical treatment (e.g., one-on-one therapy; pharmacotherapy). To our knowledge, no prior meta-analytic review has examined the effectiveness of online psychotherapeutic interventions that embed components of self-directed mindfulness practice in reducing depression and anxiety symptoms among clinician-diagnosed samples exclusively. Given this significant knowledge gap, the primary objectives of this review were twofold: 1) to unite the existing literature examining the effectiveness of multi-modal, hybrid online interventions (e.g., CBT + mindfulness) in reducing clinician-diagnosed depressive and anxiety symptoms, and 2) provide exploratory meta-analytic results to help synthesize the data to illuminate future priorities for online delivery of treatment for psychiatric disorders.

Methods

2.1 Inclusion criteria

Given a limited body of research, eligible studies selected were English language peer-reviewed RCTs assessing the impact of internet-delivered cognitive behavior treatment approaches that included *any* adjunct mindfulness component on changes in anxiety and depression (as primary or secondary outcomes) in adults (mean age ≥ 18 years) who received a clinical diagnosis of depression or anxiety via a trained clinician using a structured clinical diagnostic interview protocol. The included RCTs investigated the effects of programs delivered online or by smartphone. Only studies that provided a validated outcome measure (e.g., BDI-II and BAI) for depressive and anxiety symptoms were included.

2.1 Search strategy and search terms

Following PRISMA recommendations (Liberati et al., 2009), a systematic literature search of published randomized controlled trials was conducted from December 2017 to September 2020 using MEDLINE, PsycINFO, PubMed, CINAHL, and Web of Science databases for publications within the period of January 2000 to September 2020. Variations of the terms mindfulness, meditation, internet, online, depression, anxiety, and mental health were used. In addition, manual cross-referencing of bibliographies of trials selected for inclusion and manual searches online were completed to ensure saturation of the literature search. Citations including the title, abstract, and full-text publication were initially screened by one reviewer (MK). Two reviewers (MK & MP) then independently evaluated the citations for potentially relevant trials and obtained full-text versions of the studies selected for inclusion following PRISMA guidelines (Liberati et al., 2009).

2.2 Data abstraction and risk of bias

Relevant information from eligible studies including demographic characteristics (e.g., target population, sample size, age range), intervention characteristics (e.g., treatment protocol, duration), and specific outcomes (e.g., depression and anxiety symptoms) were independently extracted and assessed by two reviewers (MK and RW) based on an *a priori* criteria and entered into a 10-item data abstraction table. Three authors (MK, MP, RW) independently assessed the overall methodological quality of the relevant articles using the Cochrane Collaboration Tool for assessing bias (Higgins et al., 2011). To calculate overall risk of bias, studies were given a score out of 6 based on Higgins et al. (2011) criteria. Low risk of bias for each of the 6 given criteria were given a score of 1, Unknown/High risk of bias = 0. Overall, study quality was categorized with the following criteria: High quality = 5-6, Moderate Quality = 3-4, Low Quality – 0-2. Three authors (MK, MP, RW) compared overall potential risk of bias scores across selected trials (MK, MP, RW) and potential discrepancies in this process were resolved by consensus among three authors (MK, MP, RW) or consultation with a fourth reviewer (PR), amidst efforts to contact primary study authors for clarifications. Given the novelty of this review, all studies regardless of study quality were included in the overall narrative synthesis and meta-analysis.

2.3 Data Synthesis and Statistical analysis

Given the novelty of this type of treatment method, a thorough narrative synthesis of the findings from the included studies, structured around the type of intervention, clinical diagnostic protocol, type of outcome and intervention content was provided to help establish the state of the literature. Despite a limited scope for meta-analysis because of the small number of existing trials, exploratory meta-analysis was conducted using Cochrane Collaboration's Review Manager (RevMan 5.1) to provide further context. This involved calculation of a standard mean difference for anxiety and depressive symptoms (e.g., BDI-II). For each study, the effect size for the intervention was calculated as the difference in post-intervention mean values between the

intervention and control conditions. Sensitivity analysis of meta-analytic results were conducted based on selected study parameters to provide further context. Percent differences in BDI-II and scores were calculated to ascertain if a minimal clinically important difference from pre-post occurred. For BDI-II, percent differences in outcome scores were compared to the Minimal Clinically Important Difference (≥ 17.5%) according to Button et al. (2015) BDI-II criteria.

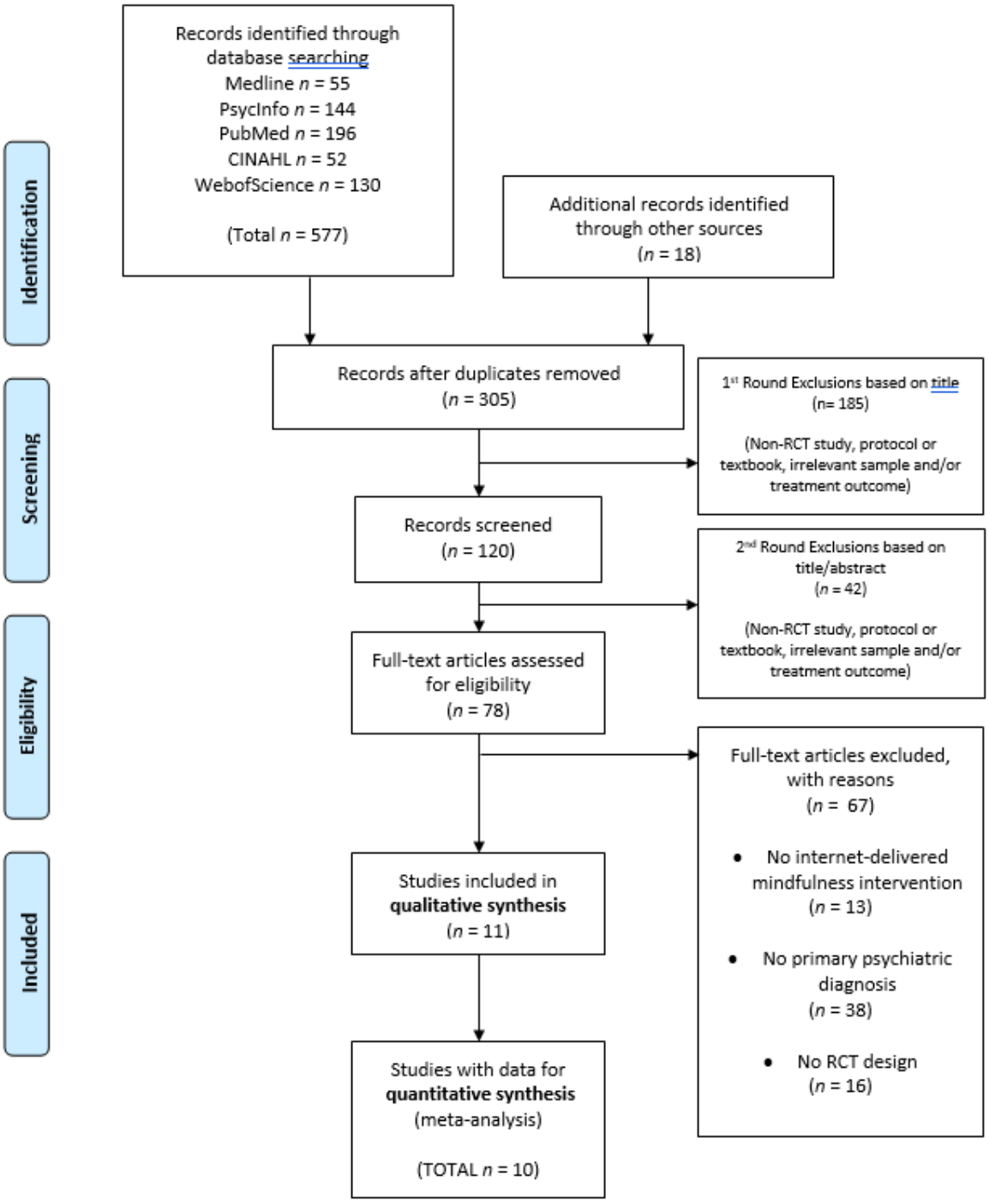
Results

3.1 Database search

Overall, the initial literature search yielded a total of 577 citations across MEDLINE (n= 55), PsycINFO (n= 65), PubMed (n= 196), CINAHL (n= 52), and Web of Science (n= 130) databases, with 18 additional citations identified by manual search. After duplicate citations were eliminated, titles and abstracts for 305 citations were initially reviewed. Of these, 185 citation titles were screened and initially eliminated in first-round exclusions based on irrelevance to our study aims (e.g., non-RCTs, protocol papers, textbooks, irrelevant population or outcome measure). The remaining 120 citations were screened by reviewing titles and abstracts to assess for eligibility based on inclusion criteria. 78 potentially relevant full-text articles were obtained for an in-depth review and the remaining 42 citations were excluded with reasons identified. Overall, a total of eleven RCTs (Berger, Hammerli, et al., 2011; Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016; Gershkovich et al., 2017; Kivi et al., 2014; Lappalainen et al., 2014, 2015; Ly, Trüschel, et al., 2014; Pots et al., 2016; Silfvernagel et al., 2012) met inclusion criteria and were critically appraised and summarized in the review (See Fig 1).

Figure 1

PRISMA Diagram of the Search and Selection Process



Narrative Review

3.2 Study and participant characteristics

Table 1 highlights the study characteristics for the eleven studies reviewed. The majority of studies (*n* = 8; 72.7%) were conducted in European countries (Sweden *n* = 6; Finland *n* = 2; Netherlands *n* = 1) with only one study being conducted in North America (Pots et al., 2016). In terms of sample characteristics, all trials examined both gender samples with predominantly female participants (range 65.0-83.5%). The mean age ranged between 32.4-51.9 years. Four trials (Boettcher et al., 2014; Dahlin et al., 2016; Gershkovich et al., 2017; Silfvernagel et al., 2012) included samples with anxiety-based diagnoses (e.g. social anxiety, panic disorder, generalized anxiety disorder) while the remaining seven limited their samples to diagnoses of depression disorders (Berger, Hammerli, et al., 2011; Carlbring et al., 2013; Kivi et al., 2014; Lappalainen et al., 2014, 2015; Ly, Trüschel, et al., 2014; Pots et al., 2016). Overall, a total of 938 participants are represented across the eleven studies. Of these, 807 (86%) participants completed both pre- and post-treatment measures and were examined in this review. A total of 348 participants (43.1%) completed a mindfulness-based treatment. Sample sizes ranged from 38 total participants (intervention *n* = 19; Lappalainen et al., 2014) to 236 total participants (intervention *n* = 71; Pots et al., 2016).

Table 1

Characteristics of trials included in this meta-analytic review (n = 11)

Author, (year),[ref] Country	**Diagnosis % Female Age M, (*SD*)**	**Enrolled (Completed) (Int/Ctrl)**	**Clinical Diagnostic Procedure (Assessment Tool)**	**Online Intervention (Weeks)**	**Mindfulness Prescription (Total Mins)**	**Outcome Measures**	**Therapist Support (Y/N)**	**Comparison**	**Results**
Berger et al., (2011) Switzerland/ Germany	MD or D 69.7% 38,8 (14.0)	76(69) (22/25/22)	Phone interview (Mini-DIPS)	ICBT with ACT *Deprexis* (10)	1 Module (N/A)	BDI	Y/N	WLC	Statistically significant decreases in BDI symptoms in both unguided and guided groups compared to WLC. No significant differences between unguided/guided groups found.
Boettcher et al., (2014) Sweden	SAD, PD, GAD 71.4% 38 (10.3)	91(84) (40/44)	Phone interview (SCID)	MBP *Schenstrom (2010)* (8)	2x/day for 6 days/week. 8 weekly modules; 12 exercises per module (960)	BAI, BDI-II	N	Supervised online discussion forum	Statistically significant decrease in BAI, BDI compared to controls along with improvements in QOL only in the intervention. Reductions in BAI sustained at 6 month follow up in intervention.
Carlbring et al., (2013) Sweden	MDE 82.5% 44.4 (13.5)	80(78) (40/38)	Phone interview (SCID)	ICBT with ACT *Depressionshjalpen* (8)	1 week module w/ CD (N/A)	BAI, BDI	Y	WLC	Statistically significant reduction in BDI compared to controls. Greater proportion of intervention participants reached remission (25% vs. 5%)
Dahlin et al., (2016) Sweden	GAD 83.5% 39.48 (10.73)	103(85) (42/43)	Phone interview (SCID-1)	MBP *Oroshjalpen ("The Worry Help")* (9)	3 modules w/CD (N/A)	GAD-IV, GAD-7, BAI, MADRS-S, PHQ-9	Y	WLC	Significant reductions in GAD symptoms (d = 0.70 – 0.98) and Depression symptoms (d = 0.51 – 0.56) in favour of the intervention group.
Gershkovich et al., (2017) USA	SAD 64.3% 31.5 (9.95)	42(37) (11/16)	Phone interview (MINI/SCID)	ICBT with ACT *Herbert et al., 2009* (8)	1 week module + weekly audio exercises (N/A)	SPAI, LSAS, SIAS, BDI-II	Y	Internet intervention w/ **no** therapist support	Significant reductions in SPAI, LSAS, SIAS, BDI-II among both groups.
Kivi et al., (2014) Sweden	MMD 66% 36.6 (11.3)	92(65) (30/35)	In-person interview (MINI)	ICBT with ACT *Depressionshjalpen* (8)	1 week module w/ CD (N/A)	BDI, BAI, MADRS-S	Y	TAU	No significant difference in mean BDI, BAI, MADRS-S post-intervention between groups as both groups saw reductions in depressive symptoms
Lappalainen et al., (2014) Finland	DD 68.4% 44.6 (14.3)	38(37) (19/18)	Phone/In-Person (DSM-IV Criteria)	IACT *Good Life Compass* (6)	12 exercises; 1 module (N/A)	BDI-II, GHQ-12	Y	Face to face ACT	Statistically significant reductions BDI-II and GHQ-12 compared to controls post intervention and at 18 month follow up. Statistically significant increase in life satisfaction post intervention and follow up
Lappalainen et al., (2015) Finland	MDE 71.8% 51.9 (12.9)	39(38) (18/20)	Phone interview (4/5 DSM-IV Criteria for MDD)	IACT *Good Life Compass* (6)	12 exercises; 1 module (N/A)	BDI-II, SLC-90, ATQ-F	Y	WLC	Statistically significant reductions in BDI-II, SLC-90, ATQ-F at post-intervention maintained by 12 month follow up.

Ly et al., (2014) Sweden	MD 70% 36.1 (10.8)	84(72) (36/36)	Phone interview (MINI)	MBCT *The Mindful Way Through Depression* (8)	3-30 minute audio exercises daily (N/A)	BDI-II, BAI, PHQ-9	Y	BA Treatment	No differences in BDI-II, BAI, PHQ-9 post-intervention between groups. BA treatment more effective among severely depressed. Mindfulness treatment more effective for those with lower initial severity of depression.
Pots et al., (2017) Netherlands	MMD 75.8 46.85 (12.06)	236 (197) (71/47/79)	Phone interview (MINI)	IACT *Living to the Full* (12)	10-15 minutes daily guided mindfulness audios (910)	CES-D, HADS-A, MHC-SF	Y	WLC/Expressive Writing Active Control	Significant reductions in CES-D scores found for IACT intervention, compared with the WLC (Cohen's d=0.56) and AC (d=0.36). 54% of IACT group saw clinically significant change post-treatment on the CES-D v. 26% in WLC and 31% in AC.
Silfvernagel et al., (2012) Sweden	GAD or PD 65% 32.4 (6.9)	57 (45) (19/26)	Phone interview (SCID)	ICBT (8)	1 week module (N/A)	PDSS, BAI, MADRS-S	Y	WLC	Statistically significant reductions in BAI, PDSS, MADRS-S at post-intervention and 12 month follow up.

Abbreviations: BA – Behavioral Activation; BAI – Beck Anxiety Index; BDI-II – Beck Depression Index; CES-D – Centre for Epidemiological Studies – Depression; DD – depression disorder; D – Dysthymia; DIPS – Diagnostic Interview for Psychiatric Disorders; GAD – generalized anxiety disorder ; GHQ-12 – General Health Questionnaire; HADS-A – Hospital Anxiety and Depression Scale; IACT – Internet Acceptance and Commitment Therapy; ICBT – Internet Cognitive Behavioral Therapy; LSAS- Leibowitz Social Anxiety Scale; MADRS-S – Montgomery-Asberg Depression Rating Scale; MBCT – Mindfulness Based Cognitive Therapy; MBP – Mindfulness Based Program; MD – Major depression; MHC-SF – Mental Health Continuum Short Form; MINI – Mini International Neuropsychiatric Interview; MMD – Mild to moderate depression; PD – panic disorder; PDSS – Panic Disorder Severity Scale; PHQ-9 – Patient Health Questionnaire; QOLI – Quality of Life Index; TAU – treatment as usual; SAD – Social anxiety disorder; SCID – Structured Clinical Interview for DSM-IV Axis I Disorders; SIAS – Social Interaction Anxiety Scale; SPAI – Social Phobia and Anxiety Inventory; WLC – Waitlist Control

3.3 Clinician diagnostic procedures

The majority of studies confirmed clinical diagnosis of a mental health disorder by trained Masters or Doctoral-level student therapist via telephone interview (n = 10; Berger, Hammerli, et al., 2011; Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016; Gershkovich et al., 2017; Lappalainen et al., 2014, 2015; Ly, Truschel, et al., 2014; Pots et al., 2016; Silfvernagel et al., 2012). Three of these studies (Carlbring et al., 2013; Dahlin et al., 2016; Silfvernagel et al., 2012), explicitly reported licensed psychologists reviewed the phone interviews and confirmed the mental health diagnosis. In terms of the diagnostic interview protocol, five studies (Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016; Gershkovich et al., 2017; Silfvernagel et al., 2012) followed the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID) protocol to confirm a mental health disorder. Four studies (Gershkovich et al., 2017; Kivi et al., 2014; Ly, Trüschel, et al., 2014; Pots et al., 2016) used the Mini International Neuropsychiatric Interview (MINI) protocol and one study used the mini-Diagnostic Interview for Psychiatric Disorders (DIPS) protocol (Berger et al., 2011). The remaining two studies (Lappalainen et al., 2014, 2015) did not use a standardized interview protocol to confirm a mental health disorder, but generated study-developed clinical diagnostic questions based on criteria from the DSM-IV.

3.4 Depression and anxiety outcome measures

In terms of primary outcome measures, all eleven studies included a depression measure. The majority of trials (n = 8; Berger, Hammerli, et al., 2011; Boettcher et al., 2014; Carlbring et al., 2013; Gershkovich et al., 2017; Kivi et al., 2014; Lappalainen et al., 2014, 2015; Ly, Trüschel, et al., 2014) evaluated the effect of the online intervention on depressive symptoms using the Beck Depression Index–II (BDI-II) followed by the Montgomery-Asberg Depression Rating Scale (MADRS-S; Dahlin et al., 2016; Kivi et al., 2014; Silfvernagel et al., 2012). Eight

(72.7%) trials measured anxiety symptoms (Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016, 2016; Gershkovich et al., 2017; Kivi et al., 2014; Ly, Trüschel, et al., 2014; Silfvernagel et al., 2012) with the majority (n = 5) using the Beck Anxiety Index (BAI).

Depression severity scores on the BDI-II at baseline (Smarr & Keefer, 2011) revealed that the majority of study participants (Berger et al., 2011; Carlbring et al., 2013; Kivi et al., 2014; Lappalainen et al., 2014; Lappalainen et al., 2015; Ly et al., 2014) scored in the moderate range of depression severity (BDI-II score: 20-28) with the exception of one study in which participants mean scores were in the mild range (BDI-II score: 14-19; Boettcher et al., 2014).

Similarly, in relation to mean anxiety severity scores on the BAI at baseline (Julian, 2011), participants in three studies (Carlbring et al., 2013; Kivi et al., 2014; Ly et al., 2014) scored in the mild to moderate range of anxiety severity (BAI score: 10-18), while across two studies (Boettcher et al., 2014; Silfvernagel et al., 2012) participants scored in the moderate to severe range (BAI score: 19-29).

3.5 Design characteristics

Among the eleven RCTs, six (54.5%) included a waitlist control comparison group (Berger, Hammerli, et al., 2011; Carlbring et al., 2013; Dahlin et al., 2016; Lappalainen et al., 2015; Pots et al., 2016; Silfvernagel et al., 2012). Four studies compared the online intervention with a second treatment condition (Boettcher et al., 2014; Gershkovich et al., 2017; Lappalainen et al., 2014; Ly, Trüschel, et al., 2014) and one study compared the intervention group with a treatment as usual comparison (Kivi et al., 2014). Nine studies examined a multicomponent intervention in which daily or weekly mindfulness practice was combined with other known psychotherapeutic treatments for depression and anxiety, notably internet-delivered ACT (Lappalainen et al., 2014, 2015; Pots et al., 2016), internet-delivered CBT (Ly, Trüschel, et al., 2014; Silfvernagel et al., 2012), or an internet-delivered blend of ACT and CBT (Berger,

Hammerli, et al., 2011; Carlbring et al., 2013; Gershkovich et al., 2017; Kivi et al., 2014). Two studies examined the effects of a mindfulness-based intervention (Boettcher et al., 2014; Dahlin et al., 2016). The majority of trials (n = 7) evaluated the effectiveness of an online intervention of eight-weeks duration (Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016; Gershkovich et al., 2017; Kivi et al., 2014; Ly, Trüschel, et al., 2014) followed by a six-week intervention (Lappalainen et al., 2014, 2015). Two studies examined online interventions lasting longer than 10-weeks (Berger, Hammerli, et al., 2011; Pots et al., 2016).

In terms of program content, ten studies followed a previously validated treatment program including *The Good Life Compass* (Lappalainen et al., 2014, 2015), *Living to the Full* (Pots et al., 2017), *Depressionshjalpen* (Carlbring et al., 2013; Kivi et al., 2014), *The Mindful Way Through Depression* (Ly, Trüschel, et al., 2014), *The Worry Help (Oroshjalpen;* Dahlin et al., 2016), *Deprexis* (Berger, Hammerli, et al., 2011), and one study (Boettcher et al., 2014) used a protocol devised by (Schenström, 2010). Seven of the eleven studies delivered the intervention via an internet-linked computer (Berger, Hammerli, et al., 2011; Boettcher et al., 2014; Gershkovich et al., 2017; Lappalainen et al., 2014, 2015; Pots et al., 2016; Silfvernagel et al., 2012) and one study solely used smartphone delivery (Ly, Trüschel, et al., 2014). The remaining three studies used a combination of an internet-linked computer and CD-DVDs (Carlbring et al., 2013; Dahlin et al., 2016; Kivi et al., 2014).

3.6 Treatment characteristics

Overall, seven studies (Berger, Hammerli, et al., 2011; Carlbring et al., 2013; Gershkovich et al., 2017; Kivi et al., 2014; Lappalainen et al., 2014, 2015; Silfvernagel et al., 2012) only provided a 1-week mindfulness module for participants to complete *during* the entire intervention and it remains unclear as to whether participants adopted a self-practice after the training module. One study provided three weekly mindfulness modules (Dahlin et al.. 2016).

None of these studies reported a prescribed set amount of mindfulness practice time, however, two studies (Lappalainen et al., 2014, 2015) provided 12 mindfulness exercises for participants to complete during a one-week module. Only three studies (Boettcher et al., 2014; Ly, Trüschel, et al., 2014; Pots et al., 2016) clearly prescribed daily mindfulness practice for the entire duration of the intervention period; with two studies (Boettcher et al., 2014; Pots et al., 2016) reporting a total amount of recommended mindfulness practice of 10-15 minutes per day or a total of 840-1050 minutes of mindfulness across the entire intervention duration.

3.7 Therapist support

All but one study (Boettcher et al., 2014) provided access to online therapist support throughout the entire treatment duration. Therapist support was predominantly provided by Masters-level student therapists (Berger, Hammerli, et al., 2011; Carlbring et al., 2013; Dahlin et al., 2016; Gershkovich et al., 2017; Lappalainen et al., 2014, 2015; Ly, Trüschel, et al., 2014; Pots et al., 2016; Silfvernagel et al., 2012); only one study provided online support from a fully-licensed therapist (e.g., licensed psychologist; Kivi et al., 2014). Support was offered primarily via printed communication through email or an online intervention software platform (Berger, Hammerli, et al., 2011; Carlbring et al., 2013; Dahlin et al., 2016; Gershkovich et al., 2017; Kivi et al., 2014; Lappalainen et al., 2014, 2015; Ly, Trüschel, et al., 2014; Pots et al., 2016; Silfvernagel et al., 2012). Two studies also offered videoconference or phone sessions with a therapist (i.e., pre-, mid-, post-treatment; Gershkovich et al., 2017; Kivi et al., 2014), and one study provided two in-person counselling sessions (i.e., pre- and post-treatment; Lappalainen et al., 2014). Overall, therapists were recommended to spend an average of 15-20 min/week communicating with participants with objectives ranging from treatment adherence, module completion, and psychotherapeutic counselling. Contact with participants ranged from unlimited number of contacts (Berger, Hammerli, et al., 2011; Carlbring et al., 2013), every other day (Ly,

Trüschel, et al., 2014), to weekly contact (Dahlin et al., 2016; Gershkovich et al., 2017; Kivi et al., 2014; Lappalainen et al., 2014, 2015; Pots et al., 2016; Silfvernagel et al., 2012). Where reported, the actual mean weekly therapist support ranged from 2 min/week (Ly, Trüschel, et al., 2014) to 15.8 mins/week Gershkovich et al., 2017) to 40 min/week (Lappalainen et al., 2014). In terms of total therapist support across the entire intervention period, mean total minutes ranged from 94.8 (*SD* = 33.5; Carlbring et al., 2013) to 240 (Lappalainen et al., 2014). Seven studies (Berger, Hammerli, et al., 2011; Dahlin et al., 2016; Gershkovich et al., 2017; Lappalainen et al., 2014, 2015; Pots et al., 2016; Silfvernagel et al., 2012) implemented email or text reminders to help improve treatment completion rates.

3.8 Mindfulness Treatment Adherence

Only three studies reported the total time participants spent in mindfulness meditation practice (Boettcher et al., 2014; Carlbring et al., 2013; Kivi et al., 2014) making it difficult to summarize the findings. Overall, total time spent reported as practicing mindfulness ranged from 4.15 hours across 6-weeks (Kivi et al., 2014) to 7.3 hours across 8-weeks (Boettcher et al., 2014). This translated to a mean of less than 10 minutes of mindfulness meditation per day. Reporting of adherence rates varied across the RCTs. According to Berger et al., (2011), 56% (*n* = 14) of participants in the therapist-guided online intervention completed the entire 10-week treatment program compared to 36% (*n* = 9) of participants in the unguided online intervention group suggesting that therapist support improves completion rate. Similarly, Gershkovich et al. (2016) reported attrition rates being significantly different between groups with the therapist supported intervention yielding higher completion rates (80%) compared to the active control without therapist support (50%). In the stand-alone mindfulness intervention (Boettcher et al., 2014), a mean of 44 (*SD* = 33.7) of the 96 mindfulness exercises (46%) were completed by participants across the 8-week treatment period translating to an average of 3.7 completed

mindfulness exercises per week. Among the RCTs that reported overall treatment module completion, rates ranged from 24% (Silfvernagel et al., 2012) to 80.8% (Dahlin et al., 2016). The majority of studies reported greater than 50% module completion rate (Berger, Hammerli, et al., 2011; Dahlin et al., 2016; Gershkovich et al., 2017; Kivi et al., 2014; Lappalainen et al., 2014, 2015; Ly, Trüschel, et al., 2014; Silfvernagel et al., 2012). No study reported a 100% adherence or module completion rate.

3.9 Methodological quality and risk of bias

Table 2 presents the assessment of risk of bias for the included studies according to Cochrane Collaboration Tool criteria (Higgins et al., 2011). There were no studies that met criteria for high quality (Score = 5-6). Of the eleven trials, nine (81.8%) provided adequate information on a randomization strategy (Berger, Hammerli, et al., 2011; Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016; Gershkovich et al., 2017; Lappalainen et al., 2015; Ly, Trüschel, et al., 2014; Pots et al., 2016; Silfvernagel et al., 2012), with only one study describing whether they employed a concealed allocation sequence (Pots et al., 2016). While it is unclear whether blinding of participants or delivery personnel had taken place across interventions, given the nature of treatment, participant or personnel blinding may not have been possible. In addition, ten of the eleven trials included small sample sizes and presented with other biases such as lack of a true control condition, and insufficient determination of relative effects of individual treatment components (i.e., mindfulness vs. ACT treatment).

Table 2.

Cochrane collaboration assessment tool for risk of bias of included trials (n = 11)

Study	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding (performance bias and detection bias) (P/T)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias	Quality Rating
Berger et al., 2011	LOW	LOW	HIGH/UNCLEAR	LOW	LOW	HIGH	4
Boettcher et al., 2014	LOW	UNCLEAR	HIGH/UNCLEAR	LOW	LOW	HIGH	3
Carlbring et al., 2013	LOW	UNCLEAR	HIGH/UNCLEAR	LOW	LOW	HIGH	3
Dahlin et al., 2016	LOW	UNCLEAR	HIGH/HIGH	LOW	LOW	HIGH	3
Gershkovich et al., 2017	LOW	UNCLEAR	HIGH/HIGH	HIGH	UNCLEAR	HIGH	1
Kivi et al., 2014	UNCLEAR	UNCLEAR	HIGH/UNCLEAR	LOW	LOW	HIGH	2
Lappalainen et al., 2014	UNCLEAR	UNCLEAR	HIGH/UNCLEAR	LOW	LOW	HIGH	2
Lappalainen et al., 2015	LOW	UNCLEAR	UNCLEAR/UNCLEAR	LOW	LOW	HIGH	3
Ly et al., 2014	LOW	UNCLEAR	HIGH/UNCLEAR	LOW	MED	HIGH	2

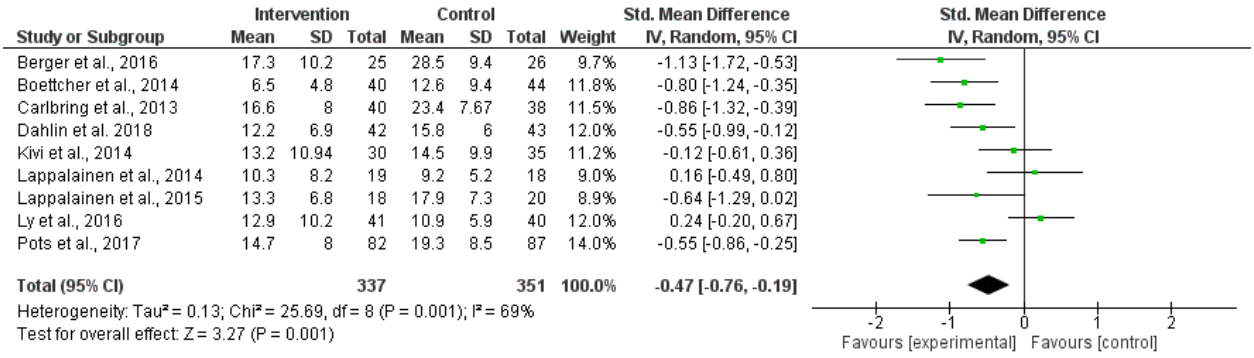
Pots et al., 2016	LOW	LOW	HIGH/LOW	LOW	LOW	HIGH	4
Silfvernagel et al., 2012	LOW	UNCLEAR	HIGH/UNCLEAR	HIGH	LOW	HIGH	2

3.10 Meta-analysis: Effect of online psychotherapeutic treatment with mindfulness for depression symptoms

Figure 2 displays the meta-analytic results for post-intervention between-group standard mean differences in depression symptoms for nine studies that included a pre-post depression outcome measure. Overall, participants in the online intervention group showed a significant reduction in overall depressive symptoms by a standard mean of -0.47 at post-intervention compared to the control conditions (SMD = –0.47 [95% CI: -0.76 to -0.19], $p < 0.001$) which equates to a moderate overall effect. Assessment of statistical heterogeneity using Chi square and I^2 indices revealed moderate (Melsen et al., 2014) significant cross-study heterogeneity ($Chi^2 = 25.69$, P = 0.0001; $I^2 = 69\%$).

Figure 2

Forest plot of depression outcomes



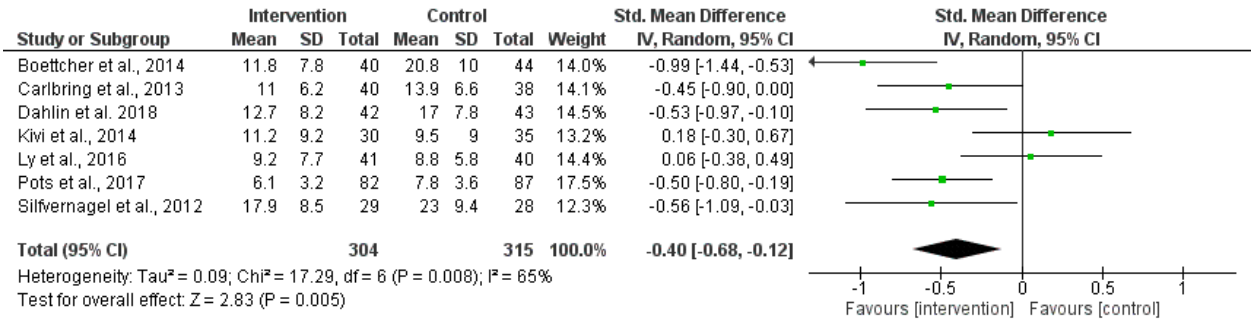
Closer examination revealed that seven (77.7%) of the nine studies (Berger, Hämmerli, et al., 2011; Boettcher et al., 2014; Carlbring et al., 2013; Kivi et al., 2014; Lappalainen et al., 2015) showed meaningful reductions in depressive symptoms in favour of the online treatment group, while two trials (Lappalainen et al., 2014; Ly, Trüschel, et al., 2014) showed a reverse trend in favour of the control condition.

3.11 Meta-analysis: Effect of online psychotherapeutic treatment with mindfulness for anxiety symptoms

Seven studies examined the effect of an online treatment program for anxiety symptoms (Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016; Kivi et al., 2014; Ly, Trüschel, et al., 2014; Pots et al., 2016; Silfvernagel et al., 2012). Meta-analyses of post-intervention between-group standard mean differences in anxiety symptoms revealed a significant moderate effect in reducing anxiety symptoms among the online intervention participants compared to the control condition (SMD = –0.40 [CI: -0.68 to -0.12], p= 0.005). Assessment of statistical heterogeneity using Chi square and I^2 indices revealed moderate (Melsen et al., 2014) cross-study heterogeneity (Chi^2 = 17.29, P = 0.008; I^2= 65%; See Figure 3).

Figure 3

Forest plot of anxiety outcomes



Further investigation revealed that five studies (Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016; Pots et al., 2016; Silfvernagel et al., 2012) showed meaningful reductions in anxiety symptoms (*Mean Difference Range* = -2.90 to -9.00) in favour of the mindfulness treatment condition while the remaining two (Kivi et al., 2014; Ly, Trüschel, et al., 2014) showed a favor toward the control condition.

3.12 Sensitivity analysis

Given the elevated heterogeneity of studies observed, further sensitivity analyses were explored by limiting meta-analytic results based on specific study parameters (i.e., theoretical orientation, delivery modality; See Table 3).

Table 3

Sensitivity Analysis Summary based on Study Parameters

Variable	Outcome Measure	Available Studies	SMD (95%CI)	I^2
Risk of Bias (QR 3-4)	Depression	6	**-0.78 (-0.88 to -0.52)**	0%
	Anxiety	4	**-0.59 (-0.82 to -0.37)**	20%
Control Condition (WLC)	Depression	4	**-0.62 (-0.83 to -0.41)**	0%
	Anxiety	4	**-0.50 (-0.71 to -0.30)**	0%
Mindfulness Rx (>1 week)	Depression	4	**-0.42 (-0.83 to -0.01)**	**76%**
	Anxiety	4	**-0.49 (-0.87 to -0.11)**	**72%**
Mindfulness-Only Treatment	Depression	3	-0.37 (-0.98 to 0.24)	**83%**
	Anxiety	3	-0.49 (-1.07 to 0.10)	**81%**
IACT-Only Treatment	Depression	3	-0.39 (-0.82 to 0.04)	50%
	Anxiety	1	**-0.50 (-0.80 to -0.19)**	--
ICBT+ACT Treatment	Depression	3	**-0.69 (-1.27 to -0.11)***	**74%***
	Anxiety	2	-0.14 (-0.76 to 0.48)	71%
Therapist Support Provided	Depression	8	**-0.43 (-0.74 to -0.12)**	**70%**
	Anxiety	6	-0.31 (-0.56 to -0.06)	51%

Bold = P <0.01; * p =0.02; SMD – standard mean difference; QR – quality rating; Rx = Prescription; WLC – Waitlist Control

As seen in Table 3, limiting meta-analytic results to RCTs that reported the lowest risk of bias (QR = 3-4) revealed the most considerable reductions in depressive symptoms (Berger et al., 2016; Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016; Lappalainen et al., 2015; Pots et al., 2016) with an overall large effect (d = -0.78) and anxiety symptoms (Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016; Pots et al., 2016) with a medium effect (d = -0.59) in favour of the online intervention group compared to controls (p < 0.01). Similarly, RCTs that compared the intervention condition with a true waitlist control condition (Carlbring et al., 2013; Dahlin et al., 2016; Lappalainen et al., 2015; Pots et al., 2016; Silfernagel et al., 2012). yielded greater reductions of depression (d = -0.62) and anxiety (d = -0.50) symptoms in favour of the intervention condition with an overall moderate-high effect. Overall, it appears that the most robust RCT designs produced the strongest reductions in clinical symptoms.

In terms of intervention characteristics and treatment components, the results were extremely varied making interpretation difficult. Mindfulness-based treatment approaches

(Boettcher et al., 2014; Dahlin et al., 2016; Ly et al., 2016) showed a non-significant effect on reducing depression symptoms (d = -0.42, p = .23) and anxiety symptoms (d = -0.49, p < .11), suggesting that stand-alone mindfulness programs may not be the most effective approach for clinician-diagnosed samples. However, caution is advised given two of these RCTs (Boettcher et al., 2014; Ly et al., 2016) compared the treatment condition with an active control group (e.g., receiving treatment) making interpretation of the mindfulness treatment effects difficult. When examining the single RCT that compared an online mindfulness-based program with a true waitlist control, results revealed a significant moderate effect in reducing depression symptoms (d = -0.55, p < .01) among the treatment group compared to the waitlist control (Dahlin et al., 2016). Ultimately, the inconsistent findings support continued RCTs to clarify treatment findings.

Limiting RCTs to those that employed an online ACT treatment (Lappalainen et al., 2014; Lappalainen et al., 2015; Pots et al., 2016) trended towards a significant effect for reducing depression symptoms (d = -0.39, p = 0.11). In terms of anxiety symptoms, only one online ACT RCT (Pots et al., 2016) examined the effect on anxiety and found a moderate effect (d = -0.50, p < .01). Studies that blended CBT with ACT components (Berger et al., 2011; Carlbring et al., 2013; Kivi et al., 2014) revealed significantly greater reduction of depression symptoms (d = -0.69, p = 0.02) in the intervention group compared to controls, with a large effect found for RCTs using a true waitlist control (d = -0.96, p <.01; Berger et al., 2016; Carlbring et al., 2013). Findings for anxiety symptoms were inconsistent; Carlbring et al. (2013) showing reduced anxiety symptoms compared to a waitlist control condition and Kivi et al. (2015) showing reductions in favor of a TAU (i.e., face-to-face contact and medications) control group. The presence of therapist support (Berger et al., 2016; Carlbring et al., 2013; Dahlin et al., 2016; Kivi et al., 2014; Lappalainen et al., 2014; Lappalainen et al., 2015; Ly et al., 206; Pots et al., 2016)

during the intervention yielded similar reductions in depression symptoms (d = -0.43, p < .01) and had a non-significant effect for anxiety (See Table 3).

3.13 Minimal clinically important difference in pre-post depression scores

According to Button et al. (2015) a minimal clinically important difference in BDI-II scores equates to a reduction of ≥17.5%. Table 4 shows the percent (%) change and Hedge's *g* effect size in depression from baseline to follow up across trials that used the Beck Depression Index-II. Of the seven studies that measures BDI-II (Berger et al., 2011; Boettcher et al., 2014; Carlbring et al., 2013; Kivi et al., 2014; Lappalainen et al., 2014; Lappalainen et al., 2015; Ly et al., 2013), online intervention groups showed on average 46.2% reduction in depression symptoms, more than 2.5 times the minimal clinically important reduction (MCID) levels (≥ 17.5%) according to Button et al. (2015) BDI-II criteria. Similar reductions (M = 45.2%) were also seen among active treatment comparison groups (e.g., face-to-face ACT, treatment as usual) but not in wait-list control groups (M = 8.3% reduction).

Table 4

Mean depression (BDI-II) and anxiety (BAI) scores, % changes from baseline to follow-up and Hedges' g effect size (n = 7)

	Intervention			Control			Hedges' *g*
Study	T1 M(*SD*)	T2 M(*SD*)	± Change (%)	T1 M(*SD*)	T2 M(*SD*)	± Change (%)	
Depression (BDI-II)							
Berger et al., 2011	28.8(8.2)	17.3(10.2)	-39.9	29.8(8.6)	28.5(9.4)	-4.4	-1.13
Boettcher et al., 2014	16.4(7.0)	6.5(4.8)	-60.4	16.2(7.3)	12.6(9.4)	-22.2	-0.81
Carlbring et al., 2013	26.3(6.0)	16.6(8.0)	-36.9	25.1(5.2)	23.4(7.7)	-6.8	-0.85
Kivi et al., 2014	25.5(7.9)	13.2(10.9)	-48.2	26.1(9.4)	14.5(9.9)	-44.4	-0.12
Lappalainen et al., 2014	20.8(9.3)	10.3(8.2)	-50.5	23.1(6.4)	9.17(5.2)	-60.3	0.16
Lappalainen et al., 2015	22.1(7.8)	13.3(6.8)	-39.8	20.6(6.8)	17.8(7.3)	-13.6	-0.64
Ly et al., 2013	24.7(9.5)	12.9(10.2)	-47.8	23.5(7.9)	10.9(5.9)	-53.7	0.24
			-46.2%			**-29.3%**	**-0.45**
Anxiety (BAI)							
Boettcher et al., 2014	24.2(8.6)	11.8(7.8)	-51.2	26.7(8.5)	20.8(10.0)	-22.1	-0.99
Carlbring et al., 2013	15.3(5.9)	10.9(6.2)	-28.8	15.4(7.0)	13.9(6.6)	-9.7	-0.45
Kivi et al., 2014	17.1(10.9)	11.2(9.2)	-34.5	16.2(10.5)	9.5(9.0)	-41.4	0.18
Ly et al., 2013	13.5(9.3)	9.2(7.7)	-31.9	14.6(9.1)	8.8(5.8)	-39.7	0.06
Silfvernagel et al., 2012	28.4(10.0)	17.9(8.5)	-37.0	27.5(8.9)	23.0(9.4)	-16.3	-0.56
			-36.7%			**-25.8%**	**-0.35**

Note. BAI = Beck Anxiety Inventory, BDI=Beck Depression Index

As no known MCID criteria exists for BAI presently, we could not evaluate whether changes were clinically-meaningful for the BAI. For anxiety outcomes, five trials assessed anxiety (Boettcher et al., 2014; Carlbring et al., 2013; Kivi et al., 2014; Ly et al., 2013; Silfvernagel et al., 2012). Overall, online mindfulness-based psychotherapeutic intervention groups showed 36.7% reduction in anxiety symptoms which was similar to active treatment comparison groups (34.4% reduction) but 2.5 times greater than wait-list control conditions (13.0% reduction).

Discussion

While prior research indicates in-person mindfulness-based psychotherapeutic interventions are a viable option for reducing anxiety and depression symptoms (Fjorback et al., 2011; Hofmann et al., 2010), this meta-analytic review focused exclusively on online delivery of such programs to *clinically-diagnosed* participants to ascertain the effectiveness of online treatment approaches and establish direction for future research. In contrast to previous reviews of online mindfulness-based therapeutic interventions (Fish et al., 2016; Spijkerman et al., 2016), which relied on self-reports of anxiety and depression symptoms as a diagnostic tool and pooled anxiety/depression outcomes across a wide variety of clinical *and* non-clinical samples (e.g. chronic pain patients, tinnitus patients, apparently healthy students or employees) without evaluating effects per specific diagnostic criteria, this present systematic review focused on treatment effects for participants diagnosed with clinical depression or anxiety disorders using standardized or DSM IV-derived structured interviews (e.g. MINI, Mini-DIPS, SCID). Our meta-analysis indicates statistically significant differences at follow up in mean depression scores in favor of online psychotherapeutic treatments that explicitly include mindfulness vs. comparison conditions (i.e., WLC, TAU, online discussion group, active treatments). Further evaluation using MCID criteria (17.5% reduction in depression scores according to Button et al. 2015) revealed a three-fold mean reduction of nearly 46% in depression symptoms from baseline

to post-intervention among the treatment groups (Table 4) suggesting that multi-modal, hybrid psychotherapeutic treatments that include mindfulness may be an important component for future online clinical treatment approaches. In addition, the findings from this review support the notion that online delivery of such interventions may be a beneficial offering to individuals currently placed on a lengthy waitlist to receive psychiatric or face-to-face psychotherapy, or as an adjunct to other psychotherapy treatments to further support symptom reduction.

Altogether, our findings show a similar effect as prior research supporting the effectiveness of in-person (Fjorback et al., 2011) and internet-delivered mindfulness-based therapeutic interventions in addressing depressive symptoms in blended nonclinical and clinical populations (Cavanagh et al., 2014; Spijkerman et al., 2016). To establish direction for future research, we reviewed RCTs that explicitly included a component mindfulness as part of a multicomponent approach combined with CBT, ACT or CBT-ACT combined, regardless of prescription duration. Because each intervention component may uniquely contribute to overall effects, it was difficult to discern which sub-components of the intervention had the largest effects (e.g., mindfulness vs. CBT) on symptom reduction. Within the RCTs reviewed, the interventions with the largest reduction in depressive symptoms appeared to be those with multicomponent approaches (CBT + ACT + mindfulness meditation; Carlbring et al., 2013) compared to stand-alone mindfulness which has important implications for future online clinical treatment development .

Recent findings by Karyotaki et al. (2017) indicate that self-guided, internet-linked CBT resulted in significant reductions of depressive symptom severity when compared with control conditions in a review of 13 RCTs. While these findings are notable for future clinical best-practice, the question arises about whether there are added benefits when CBT-type interventions are combined with mindfulness and therapist-support? While the Karyotaki (2017) review and

our review support the efficacy of internet-linked, cognitive behavioral interventions, it is challenging to ascertain the relative value of these respective interventions (i.e., online mindfulness-based cognitive behavioral vs. self-guided, internet-linked cognitive behavioral). In terms of mean effect size per studies reviewed (n = 13 in Karyotaki et al. and n = 7 in this review), Karyotaki et al. (2017) reported a mean Hedges g = -0.27 (small effect) for reduction of depressive symptom severity while our calculations yielded an even greater (moderate) effect Cohen's *d* = -0.47, pointing to the added benefits of including mindfulness and therapist-support as important adjuncts to online therapeutic treatment. Furthermore, in the thirteen studies analyzed by Karyotaki et al. (2017), we see the review as hampered by the same merging of diagnosed and non-diagnosed samples as previous reviews of online delivery of cognitive behavioral approaches. Our specific review of *clinician-diagnosed samples* has allowed identification of online multi-modal treatment approaches yielding an average of 45.6% reductions in clinical depression symptoms when compared with control populations.

As with other internet-delivered treatment approaches (Melville et al., 2010), adherence with the treatment protocol was underreported and completion rates varied across studies, with an average of 85% of participants (range= 71-97%) completing post-treatment measurements. In terms of adherence, among RCTs that reported treatment module completion criteria, a majority of participants did not complete every module (Melville et al., 2010). Among RCTs included in this review, intervention duration (e.g., amount of time spent in each session practicing mindfulness) and frequency (e.g., number of mindfulness sessions per week) varied substantially. Interestingly, the RCTs in this review that reported the highest reductions in depression and anxiety symptoms had the highest reported mindfulness practice durations (Boettcher et al., 2014; Carlbring et al., 2013; Dahlin et al., 2016; Ly et al., 2014; Pots et al., 2016) suggesting a dose-response effect with more mindfulness practice built in to the treatment

approach. For example, the greatest amount of time spent practicing mindfulness, a total of 7.3 hours across an eight-week intervention, was associated with the largest overall reductions in anxiety symptoms (Boettcher et al., 2014). Remarkably, this amounted to less than 10-minutes of mindfulness practice daily, deviating substantially from the MBSR or MBCT treatment program home practice prescriptions of 45-60 minutes per day (J. Kabat-Zinn, 2013; Segal et al., 2012). Our review points towards smaller prescriptions of daily mindfulness in increments of 5-10 minutes as potentially more realistic and manageable for clinician-diagnosed populations who are concurrently receiving treatment for negative cognitions (e.g., persistent low mood, low self-worth, poor concentration, loss of interest or pleasure) and uncomfortable somatic sensations (e.g., fear, hypervigilance, hyperarousal) characteristic of their psychiatric diagnosis (WHO, 2016). Further evaluation of the relationships between smaller dosages of mindfulness and treatment outcomes among clinician-diagnosed populations are needed to substantiate these findings.

The growing demand for online delivery of psychotherapeutic programs to support self-management and lifestyle modification to treat psychiatric disorders requires clarification of the frequency and duration of self-directed, at-home mindfulness practice most strongly associated with the greatest reductions of anxiety and depressive symptoms. Such clarification would help establish evidence-based treatment recommendations and guidelines. Previous reviews examining the dose-response relationship between mindfulness and health-related outcomes have indicated that smaller doses of daily mindfulness practice are beneficial for program adherence and improving mental health (Strohmaier, 2020), however inherent limitations surrounding self-report and recall methods to capture program adherence remain an ongoing challenge. The integration of novel wearable health devices that assess objective psychophysiological responses reflecting autonomic function (e.g., heart-rate-variability) and adherence levels (e.g., tracking via

mobile app) have the potential to further enhance online mental health and comorbid disease symptom management without having to rely on self-report methods. Validated and approved wearable devices such as the European Society of Hypertension approved SOMNOtouch NIBP (www.somnomedics.de) include assessments of 24 hour heart rate variability, an established biomarker of autonomic dysregulation in clinically depressed populations (Hartmann et al., 2018), to arrive at more precise evaluation of psychophysiological responses and program adherence to prescribed self-directed mindfulness practice (Berka et al., 2004). Future trials would benefit from exploring the integration of objective wearable technologies. Overall, the findings from this review highlight the need to investigate the dose-response relationship between meditation practice adherence with symptom reduction using more reliable, objective, and consistent methods to validate mindfulness as an effective adjunct to online psychotherapeutic treatment.

Furthermore, the findings from this review indicate that online multi-modal psychotherapeutic programs that include online therapist support yield similar changes in symptoms as face-to-face formats (Andersson & Cuijpers, 2009; Cavanagh et al., 2014; Spijkerman et al., 2016)(Fjorback et al., 2011; Segal et al., 2012) and even greater reductions in symptoms than stand-alone, self-guided interventions with no therapist contact (Karyotaki et al., 2017). The role of the therapist appears to be an important moderator of treatment-specific outcomes, yet presents challenges when resources are limited. Thus, future research may benefit from the exploration of automated systems that track online usage and performance and can send a reminder text or email prompt to motivate adherence as a way to further advance online treatment adherence (Malpass et al., 2012). Additionally, access to a phone-based health coach or therapist trainee to help participants identify goals, clarify treatment expectations and establish an internet-based therapeutic alliance may translate into higher adherence rates and symptom

management as a result of increased patient accountability (Malpass et al., 2012; Mohr et al., 2011). Future studies investigating the contributions of wearable devices, automated messaging and virtual clinician support are recommendations for future online mental health treatment interventions.

Overall, the therapeutic interventions that included an adjunctive mindfulness practice show promise, however, the heterogeneous nature of the trials included in this review highlight the need for continued focused research. First, RCTs examined in the current review had small sample-sizes and predominantly female populations that limit generalizability. Future RCTs investigating larger sample-sizes, with more balanced gender-based composition would enhance generalizability. Second, amongst the RCTs that reported significant symptom reductions, each compared the treatment condition to a waitlist control condition which may have resulted in exaggerated treatment effects than if the comparisons were undertaken with an attentional control condition. Third, due to the heterogeneity of studies reviewed, we were unable to ascertain which therapeutic program components were most responsible for symptom reductions. Future RCTs comparing and contrasting both blended and stand-alone mindfulness vs. psychotherapy treatment approaches would help identify the mechanisms most responsible for treatment effects. Fourth, the studies reviewed relied heavily on initial recruitment from public and academic settings using self-reported anxiety and depression which may have resulted in a reporting bias as this type of recruitment method typically results in highly-motivated samples. Despite all studies confirming a mental health disorder via third-party interview, only one study included clinically-diagnosed participants by a licensed clinician (Kivi et al., 2014), indicating a greater need for research specifically with clinical referrals to help establish recommendations for clinical treatment.

The findings of this systematic review need to be interpreted within the context of its limitations. First, the existing literature examining the effectiveness of online hybrid psychotherapeutic and mindfulness-based approaches among clinically-relevant populations is limited. Thus, this review and meta-analysis may risk bias as a result of a small number of RCTs, varied study quality, and overrepresentation of studies in Scandinavian countries. Second, the intervention type (e.g., CBT, ACT, CBT+ACT), mindfulness prescription, and type of control/comparison groups varied considerably across included studies and warrants caution in interpreting the calculated effects sizes. Although we made attempts to conduct sensitivity analysis to ascertain what treatment approach yielded the greatest effects, the analyses are largely underpowered and exploratory making interpretation and generalizability difficult. Finally, only three studies provided explicit details on self-guided mindfulness prescription which is not sufficient to conduct a full review or meta-analysis. Future research that captures objective details about the prescribed versus actual mindfulness practice using a combination of wearable technology, automated reminders, and virtual therapist support are a priority. Despite these limitations, the practice of mindfulness has gained considerable traction as an effective adjunct and possible stand-alone approach in treating clinical mental health conditions. Thus, this review provides a preliminary contribution to the understanding of the added effects of combining mindfulness with psychotherapy in clinician-diagnosed samples and encourages future clinical trials to address the gaps that have been outlined.

Conclusions

Internet-delivered cognitive-behavioral interventions that include mindfulness-based self-guided components appear as effective and acceptable as traditional psychotherapeutic programs delivered face-to-face. In summary, our findings support the application of online cognitive behavioral intervention with adjunctive mindfulness-based practices for reducing depression and

anxiety symptoms in clinician-diagnosed populations. These results are timely given the current global pandemic and subsequent rapid expansion of internet-delivered psychiatric treatments to address a growing mental health crisis across the globe. This review suggests that online mindfulness-based psychotherapeutic programs would benefit a potentially large population of under-served diagnosed individuals struggling with clinical depression and anxiety.

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Appendix B: Study Participant Recruitment Flyer

Appendix C: Participant Informed Consent Form

Informed Consent Form

Research Study Title
An online trauma-informed yoga and mindfulness meditation program for young adults with symptoms of PTSD

Principal Investigator:
Megan A. Kirk Chang, PhD Candidate
School of Kinesiology & Health Science
York University
Email: [insert email]
Office: Stong Building, Rm 361

Supervisor:
Dr. Paul Ritvo, PhD, C. Psych.
Professor
School of Kinesiology & Health Science
York University
Email: [Insert email]
Office: Chemistry Building, Rm 136

You are being asked to take part in a research study titled ***An online trauma-informed yoga and mindfulness meditation program for young adults with posttraumatic stress disorder (PTSD)*** that is being conducted by Megan Kirk Chang, a doctoral-level graduate student in the School of Kinesiology and Health Science at York University. The information outlined below will help you make an informed decision about whether or not you wish to participate in this research study. This is known as the informed consent process. Please ask the researcher to explain any words or points that you do not understand fully before signing this consent form. Take as much time as you need to make your decision and make sure all of your questions have been answered to your satisfaction and comfort level before signing this document.

Purpose of the Research: Recent studies show yoga, an exercise format often coordinated with meditation, can reduce symptoms related to traumatic events (e.g. anxiety and depression). In this study we evaluate an 8-week online, tailored, yoga-meditation program for young adults, (18-35years), who have experienced a traumatic event and now experience associated symptoms.

Young adults can experience one or more traumas (e.g., physical assault, car accident, terrorism, weather disaster, etc.) and associated nightmares, flashbacks, anxiety, depression, insomnia, extreme stress and other symptoms reflecting PTSD. This study aims to reduce symptoms and improve symptom management. This online intervention aims to make participation more effective, efficient and convenient. An important feature is personalized weekly telephone-based health coach support with coaches trained and supervised by Dr. Ritvo (a registered clinical psychologist and Professor).

By investigating the effectiveness of the program for youth affected by PTSD, we hope to better understand benefits and the experiences and characteristics of PTSD.

We will assess psychological and physical PTSD symptoms before and after the 8-week program using a standardized clinician administered interview (Clinician Administered PTSD Scale (DSM-5)). Additional symptoms and conditions will be assessed by selfreport questionnaires found to be accurate and valid measures of anxiety, depression, and PTSD. We will additionally use wearable technologies (i.e., TobiiPro glasses, ECG machine) to better understand the physical effects of PTSD and intervention benefits.

This research is being conducted by Megan Kirk Chang (MKC) as part of her doctoral dissertation requirements. The study has received ethics review and approval by the York University Human Participants Review Sub-Committee of York University's Ethics Review Board. Findings will be reported in peer-reviewed academic journals and presented at regional, national, and international conferences to

inform research strategies aimed at reducing trauma symptoms in young adults.

What You Will Be Asked to Do in the Research: If you agree to participate in the study, the length of time commitment is approximately 10-12 weeks. If you agree to participate, you will be asked to complete a standardized in-person interview with a trained clinician, and online questionnaires to help us understand your experience with trauma and associated symptoms. Overall, there are six assessments (3 at baseline and 3 at 8-week follow-up). You will be asked to complete two in-person interviews (60-75 minutes) 8-weeks apart and two online surveys (20-25 minutes) 8-weeks apart. You will also be asked to participate in two lab tests (30 minutes) measuring your heart rate and pupil response to a series of pictures on a computer screen 8-weeks apart.

Interview & Online Surveys: You will participate in an in-person interview with a trained research assistant that will last approximately 60 minutes. During this interview, a trained research assistant will be asking a specific set of questions regarding your trauma experience to better understand your current symptoms. Following the interview, you will then complete a 25-minute online survey asking you more detailed questions regarding your current mood, mental health symptoms, and general health.

Psychology Lab Testing: Within 7-days of completing the baseline interview and surveys,you will complete a 30-minute lab test to undergo a specific test to measure your heart rate and pupil (eye) reaction. You will be asked to wear special eye glasses (i.e. TobiiPro Eye-Tracking Glasses) and be connected to an electrocardiography machine (ECG) and respiration belt. These are special devices that help us measure changes in your pupils (eyes) and changes in your heart. The devices used (e.g., electrocardiogram unit, respiration belt, and TobiiPro Glasses) record physiological data of the participants eyes, heart, and breath rate in response to an emotional stimulus. The physiological data gives us important information on how the body responds to emotional stimuli before and after an intervention. Overall, the test consists of a 5-minute baseline measurement, a 10-minute emotional image viewing task of 60 images that reflect different emotions (e.g., anger, sadness, fear), and a 10-minute guided meditation + positive emotional image viewing task (e.g., happy, calming). We will aim to schedule the lab test as best as possible with your schedule. There may be a time where this does not work within a one-week period, and we will work with you to select a day and time that works best with your schedule. If you choose not to participate, we will ask for your permission to collect information about your reason for refusal.

Trauma-Informed Yoga Program: Prior to starting the 8-week trauma-informed yoga program with health coach support, you will have an orientation with your health coach to understand the program content. All participants will receive a yoga mat at orientation as a thank-you for participating in the research study. A certified, specially trained yoga instructor leading the online program explains the yoga program in more detail through a series of online videos explaining how to complete each yoga posture safely, and answer any additional questions. Participants will then receive a password protected online link to a website, www.healmytraumaimprint.com, where they have access to guided audio meditations, yoga videos, and a breath manual. Participants will also have the option to access additional weekly live-stream online yoga and mindfulness sessions in the comfort of their own home or convenient location where they can participate in a structured yoga and/or meditation session. Participants will be asked to wear comfortable clothing, to find a quiet area to practice the yoga postures, and to do their best to follow the online program. A trained health coach will connect with participants weekly via videoconference (www.zoom.us) at agreed times during the 8-week program. Your access to a health coach will further assist you to with overcoming any challenges related to the yoga program such as program attendance, barriers to regular practice, and goal-setting.

The following table summarizes the research tests and procedures

Time-Period (Visit)	Tests and Procedures	Purpose
Pre-Screening	Life Events Checklist (LEC-5) Questionnaire (5-minutes)	Determine trauma exposure
Baseline Measures	**In-person Interview** (45-60 minutes) Clinician Administered Posttraumatic Stress Scale (CAPS-5) **Online Survey** (25 minutes) Basic demographics Quality of Life & Health Survey (SF-36) PTSD Checklist – Civilian Version (PCL-5) Pain Catastrophizing Scale (PCS) Brief Pain Inventory (BPI) Beck Anxiety Inventory (BAI) Beck Depression Index – II (BDI-II) Five Facets of Mindfulness Questionnaire (FFMQ)	Determine study eligibility Establish PTSD criteria Determine PTSD symptom severity Determine comorbid conditions symptom severity
*Option to book same-day or within 7days of interview/survey	**Psychology Lab Testing** (30minutes) Pupillometry Procedure* Heart rate variability measurement*	To establish baseline pupil reaction and HRV using emotional images
8-Week Intervention Period	**Intervention group – Yoga Program** (1 in-person orientation (60-minutes) + 8 online yoga sessions (1x/week); weekly home-based practice resources; health coach support)	To investigate the effectiveness of an online home-based yoga program for young adults with PTSD symptoms.
Post-Intervention Measures	**In-person Interview** (45-60 minutes) Clinician Administered Posttraumatic Stress Scale (CAPS-5) **Online Survey** (15-20 minutes) Basic demographics Quality of Life & Health Survey (SF-36) PTSD Checklist – Civilian Version (PCL-5) Beck Anxiety Inventory (BAI) Beck Depression Index – II (BDI-II) Five Facets of Mindfulness Questionnaire (FFMQ)	Determine PTSD symptom severity Determine comorbid conditions symptom severity
*Option to book same-day or within 7days of interview/survey	**Psychology Lab Testing** (30-45 minutes) Pupillometry Procedure* Heart rate variability measurement*	To establish baseline pupil reaction and HRV using emotional images

Post-Treatment Period Testing: After the 8-week intervention period, participants will be asked to complete the post-intervention measures which include the standardized in-person interview, an online survey, and psychology lab test (see Table above). If you agree to participate, the baseline and post-intervention assessments last approximately 1.5-2 hours. If it is more convenient for you to complete the assessment on 2 separate days, we can arrange this. Overall, the intervention period is 8-weeks; you will be in this research study for approximately 10-12 weeks depending on when your assessments are booked and completed.

Risks and Discomforts: There may be a possibility of a minimal level of emotional discomfort completing the in-person interview or emotional image viewing task as it requires the participant to potentially discuss and relive a past traumatic event and disclose symptoms. To address this, the interviewer has undergone rigorous training and supervision to administer the standardized Clinician Administered Posttraumatic Stress Scale (CAPS-5) interview with the utmost care and concern for the wellbeing of the participant. If the emotional discomfort is too much for the participant, the interviewer will stop the interview immediately

and refer the participant to Dr. Paul Ritvo, the research supervisor, who is a registered clinical psychologist to ensure the participant receives appropriate support and/or referrals to various mental health services. All research staff involved in this study work in close supervision with Dr. Paul Ritvo to ensure any emotional discomfort among participants is handled appropriately. All yoga sessions have been developed by a Canadian Yoga Alliance (CYA) Registered 250+hour Yoga Teacher with 30-hours of specialized training in trauma-informed yoga and have been cross-checked by a second CYA Registered Yoga Teacher with the same trauma-informed yoga training who is not involved in the study. You may experience slight muscle soreness 24-72 hours after the yoga sessions. Although this may be slightly uncomfortable, it is a normal response from the yoga program and should resolve on its own. If it does not, please contact the principal investigator, **Megan Kirk Chang** at **[insert email].**

Benefits of the Research and Benefits to You: You may or may not receive any physical, mental, or emotional benefit from your participation in this study. It is our hope that your PTSD symptoms and overall health improve with the help of this study. The information participants provide may benefit other young adults who face similar circumstances to your own.

Voluntary Participation and Withdrawal: Your participation in the study is **completely voluntary** and you may choose to stop participating at any time. Your decision not to volunteer, to stop participating, or to refuse to answer particular questions **will not** influence the nature of the ongoing relationship you may have with the researchers or study staff, or the nature of your relationship with York University either now, or in the future. If you decide to stop participating, you may withdraw without penalty, financial or otherwise, and you will still receive a yoga mat for your participation in the study. In the event you withdraw from the study, all associated data collected will be immediately destroyed **upon your request**. Should you wish to withdraw after the study, you will have the option to also withdraw your data up until the analysis is complete.

Confidentiality: All information obtained during the study, including your personal interview and survey responses, and psychology lab tests, will be kept confidential and will not be shared with anyone outside the study unless required by law. All hard-copy data from participants (e.g., interview responses, psychology lab tests) will be safely stored in a locked file cabinet in a locked facility that only the research staff on this study will have access to. Electronic data for analysis will be stored on a password protected computer that only the principal investigator and supervisor knows; the computer also requires facial recognition of the principal investigator to access the files as an added security measure.

The online survey questionnaire data uses encrypted software that requires a case-sensitive password only known by the primary investigator and her academic supervisor. The researcher(s) acknowledge that the host of the online survey (e.g., Qualtrix, Survey Monkey, etc.) may automatically collect participant data without their knowledge (i.e., IP addresses). Although this information may be provided or made accessible to the researchers, it will not be used or saved without participant's consent on the researchers system. Further, because this project employs e-based collection techniques, data may be subject to access by third parties as a result of various security legislation now in place in many countries and thus *the confidentiality and privacy of data cannot be guaranteed during web-based transmission.*

Data will be retained until August, 2026, for five years after the publication of the study results. After this period, all study-related data will be destroyed via secure paper shredding and deletion of files from the hard-drive by the principal investigator. Results from this study may be used in subsequent peer-reviewed scholarly journals, oral and poster presentations, teaching purposes, and other research investigation. You **will not** be named in any reports, publications, or presentations that may come from this study. All results from this study will be identified as **group data only, with no personal identifiers.** Unless you choose otherwise, all information you supply during the research will be held in confidence and unless you specifically indicate your consent, your name will not appear in any report or publication of the research. Confidentiality will be provided to the fullest extent possible by law.

The data collected in this research project may be used – in an anonymized form - by members of the research team in subsequent research investigations exploring similar lines of inquiry. Such projects will

still undergo ethics review by the HPRC, our institutional REB. Any secondary use of anonymized data by the research team will be treated with the same degree of confidentiality and anonymity as in the original research project.

Questions About the Research? If you have questions about the research in general or about your role in the study, please feel free to contact me at [insert email] or my supervisor, Dr. Paul Ritvo, at [insert email] and/or [XXX-XXX-XXXX]. You may also contact the Graduate Program in Kinesiology and Health Science at kahs@yorku.ca and/or (416) 736-5728.

This research has received ethics review and approval by the Delegated Ethics Review Committee, which is delegated authority to review research ethics protocols by the Human Participants Review Sub-Committee, York University's Ethics Review Board, and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this process, or about your rights as a participant in the study, please contact the Sr. Manager & Policy Advisor for the Office of Research Ethics, 5th Floor, Kaneff Tower, York University (telephone 416-736-5914 or e-mail ore@yorku.ca).

Legal Rights and Signatures:

I_____consent to participate in ***An online trauma-informed yoga and mindfulness meditation program for young adults with PTSD*** conducted by Megan A. Kirk Chang, PhD Candidate. I have understood the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

Signature_____ **Date**_____
Participant

Signature_____ **Date**_____
Principal Investigator

Additional consent

1. Consent for Email Communications

If you agree, the research team can communicate with you using email. However, there are certain risks of using email that need to be disclosed including: 1) the security of email messages is not guaranteed. Messages sent to, or form, the York University research staff for this study may be seen by others using the internet. E-mail is easy to forge, may be accidentally forwarded, and may exist indefinitely. For this reason, it is recommended that you do not use email to discuss information that you think is sensitive or private. If you consent to using email, please tell the principal investigator, Megan Kirk Chang, if there are certain types of information that you do not want to discuss by email, and 2) **do not use email if you are in a crisis** or emergency since email can be delayed or members of this research team may not be able to read and respond soon enough.

Please note:

- The research team on this study will talk to you about which types of conversations you are all comfortable having over email (e.g., scheduling assessments).
- A member of this research team may not feel comfortable discussing some topics by email (e.g. your survey results) and will tell you if another way will be used.
- Email may be forwarded to Dr. Ritvo, Megan Kirk Chang, Health Coaches, or Research Assistants who need the information to provide you with the appropriate care. You will be informed if another person will read or reply to your email.
- If you decide that you no longer want to communicate by email please tell a member of the research team listed below as soon as possible.

I, _____ consent to receiving email communication about the current study by the following research staff:

- ☐ Principal investigator, Megan A. Kirk Chang
- ☐ Supervisor, Dr. Paul Ritvo
- ☐ Health Coach for this specific study
- ☐ Research Assistant for this specific study

The best email to contact me at is: _____

Signature: Date:

_____ _____

Participant: (name)

Latest Version: July 31, 2019

2. **Audio, Photographic & Video recording**

Photographic/Still Recording – As part of the objective measure of autonomic regulation and PTSD symptoms, participants will undergo a lab assessment to establish pupillary (eye) and heart-rate-variability response to an emotional stimulus (e.g., pictures of emotional images). The devices used (e.g., electrocardiogram unit, respiration belt, and TobiiPro Glasses) record physiological data of the participants eyes, heart, and breath rate in response to an emotional stimulus. The physiological data gives us important information on how the body responds to emotional stimuli before and after an intervention. All physiological data will be stored on a password protected, safe and secure computer that is only accessible to the primary investigators. Prior to the lab assessment, each participant is given an alphanumeric identifier to anonymize the data. All physiological data files will be labelled with a unique identifier that contains no identifying information of the participant. Dissemination of this data will be based on **group-data** only with no individual information being shared or identified. The physiological data will be kept on a secure, password protected computer located in a locked laboratory office that only the primary investigators have access to. Data will be retained until August, 2026, for five years after the publication of the study results. After this period, all study-related data will be destroyed via secure paper shredding and deletion of files from the hard-drive by the principal investigator. Results from this study may be used in subsequent peer-reviewed scholarly journals, oral and poster presentations, teaching purposes, and other research investigation. You **will not** be named in any reports, publications, or presentations that may come from this study. All results from this study will be identified as **group data only, with no personal identifiers.** Unless you choose otherwise, all information you supply during the research will be held in confidence and unless you specifically indicate your consent, your name will not appear in any report or publication of the research. Confidentiality will be provided to the fullest extent possible by law.

Online Live-Stream Yoga Sessions: The online intervention program may offer the option to participate in weekly live-streamed, online mindfulness and yoga sessions using a secure and free videoconference software (www.Zoom.us), once per week for 60-minutes, for a total of 480-minutes of guided instruction. Participants will have an SSL encrypted access link to the videoconference sessions. The videoconference host (MKC) has set up the online meeting room as one-way instruction which means when participants log on, they are automatically muted and blinded from being seen. Participants who wish to remain anonymous must keep their microphone and video camera muted. Participants will be reminded that participation in the live sessions is completely voluntary. Because there is an option for participants to turn on their own microphone or video camera, full anonymity is not entirely possible. To remedy this, participants will be reminded at the start of the session that they are muted and blinded to the group and if they want to speak or ask a question, it is entirely voluntary. The live-streamed sessions are a way to provide real-time instruction that mimics the experience of going to a real session. Participants' participation is completely voluntary and they may withdraw from the session at any time. Individual yoga sessions may be provided to participants at the explicit request of the participant. There is no guarantee that sessions outside the allotted weekly time will be available, but every effort will be made to accommodate participants.

- ☐ I consent to the photographic/still recording of my autonomic nervous system including my heart rate variability using the ECG machine and pupillometry using the TobiiPro glasses.
- ☐ I understand and consent to the nature of the online live-stream guided mindfulness and yoga sessions. I understand that my participation in the live-stream sessions is optional.

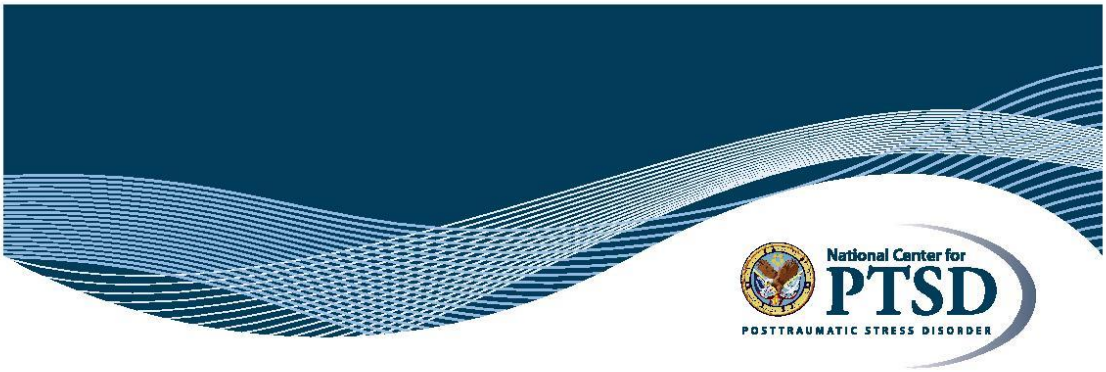
Signature: Date:

_____ _____

Participant:

Latest Version: July 31, 2019

Appendix D: Psychometric Questionnaire Instruments



Life Events Checklist for *DSM-5* (LEC-5)

Standard Version

Version date: 12 April 2018

Reference: Weathers, F. W., Blake, D. D., Schnurr, P. P., Kaloupek, D. G., Marx, B. P., & Keane, T. M. (2013). *The Life Events Checklist for DSM-5 (LEC-5) – Standard.* [Measurement instrument]. Available from https://www.ptsd.va.gov/

URL: https://www.ptsd.va.gov/professional/assessment/te-measures/life_events_checklist.asp

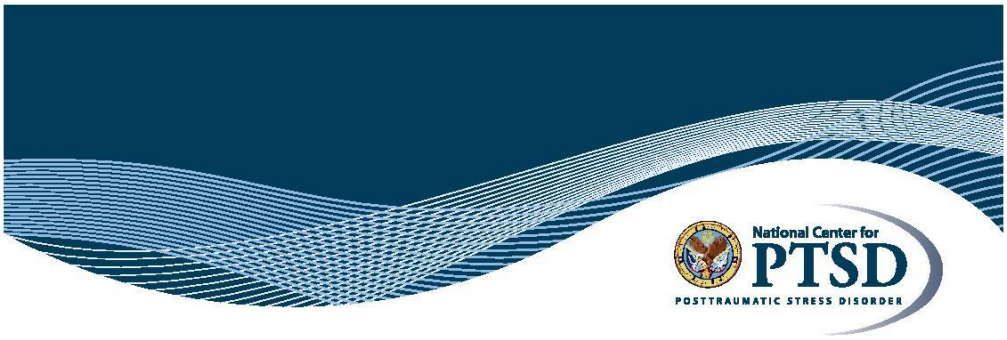
Note: This is a fillable form. You may complete it electronically.

LEC-5 Standard

Instructions: Listed below are a number of difficult or stressful things that sometimes happen to people. For each event check one or more of the boxes to the right to indicate that: (a) it happened to you personally; (b) you witnessed it happen to someone else; (c) you learned about it happening to a close family member or close friend; (d) you were exposed to it as part of your job (for example, paramedic, police, military, or other first responder); (e) you're not sure if it fits; or (f) it doesn't apply to you.

Be sure to consider your *entire life* (growing up as well as adulthood) as you go through the list of events.

Event	Happened to me	Witnessed it	Learned about it	Part of my job	Not sure	Doesn't apply
1. Natural disaster (for example, flood, hurricane, tornado, earthquake)						
2. Fire or explosion						
3. Transportation accident (for example, car accident, boat accident, train wreck, plane crash)						
4. Serious accident at work, home, or during recreational activity						
5. Exposure to toxic substance (for example, dangerous chemicals, radiation)						
6. Physical assault (for example, being attacked, hit, slapped, kicked, beaten up)						
7. Assault with a weapon (for example, being shot, stabbed, threatened with a knife, gun, bomb)						
8. Sexual assault (rape, attempted rape, made to perform any type of sexual act through force or threat of harm)						
9. Other unwanted or uncomfortable sexual experience						
10. Combat or exposure to a war-zone (in the military or as a civilian)						
11. Captivity (for example, being kidnapped, abducted, held hostage, prisoner of war)						
12. Life-threatening illness or injury						
13. Severe human suffering						
14. Sudden violent death (for example, homicide, suicide)						
15. Sudden accidental death						
16. Serious injury, harm, or death you caused to someone else						
17. Any other very stressful event or experience						



CLINICIAN-ADMINISTERED PTSD SCALE FOR *DSM-5*

Past Month Version

Version date: 01 May 2015

Reference: Weathers, F. W., Blake, D. D., Schnurr, P. P., Kaloupek, D. G., Marx, B. P., & Keane, T. M. (2015). *The Clinician-Administered PTSD Scale for DSM-5 (CAPS-5) – Past Month* [Measurement instrument]. Available from http://www.ptsd.va.gov/

URL: http://www.ptsd.va.gov/professional/assessment/adult-int/caps.asp

Name: _____

Interviewer: _____

Study: _____

ID#: _____

Date: _____

PLEASE NOTE: The American Psychological Association's ethical guidelines on psychological test instruments require advanced graduate level training in the administration and interpretation of psychodiagnostic assessment instruments. Thus, access to these measures requires proof of clinical status or research credentials. To obtain this scale complete the online request form.

Participant Demographics and Socioeconomic Status Questionnaires

Baseline Trauma-Informed Yoga RCT - Online Survey (MKC)

Online Survey

Research Study Title
An online trauma-informed yoga program for young adults with PTSD:
A randomized controlled trial

Demographic Questions:

* 1a. First Name and Last Name initial (e.g., Megan K):

1b. Student ID #

4. With which gender do you identify with:

- ◯ Male
- ◯ Female
- ◯ Other (please specify):
- ◯ Prefer not to disclose

5. Ethnicity/Race (please fill in):

6. Were you born in Canada?

- ◯ Yes
- ◯ No

If no, what country were you born in? (Please specify):

How many years did you live in the country you were born in? (Please specify):

3

7. If you were born outside of Canada, how long have you been living in Canada? (Please write N/A if not applicable):

8. How many countries in total have you lived in? (Please specify):

9. Education status:

- 1st year Undergraduate Degree
- 2nd year Undergraduate Degree
- 3rd year Undergraduate Degree
- 4th year or more Undergraduate Degree
- Currently pursuing a 2nd degree (Masters, MBA, 2nd Undergraduate Degree)
- Currently pursuing a 3rd degree (Masters, PhD, 3rd Undergraduate Degree)
- Other (please specify):

10. Area of study (Please specify):

11. Living situation

- I live with my blood-related family members (e.g., parents) or legal guardians
- I rent and live on my own
- I rent and live with 1 other person
- I rent and live with 2 or more people
- I own my own home and live on my own
- I own my own home and live with 1 other person
- I own my own home and live with 2 or more people
- Other (please specify):

12. Marital Status:

- Single
- Dating
- Common-Law (live with partner for > 6months)
- Married
- Separated/Divorced
- Widowed

13. Employment Status:

- ◯ Currently unemployed (0 hrs/wk)
- ◯ Part-time (0-35 hrs/wk)
- ◯ Full-Time (35-40 hrs/wk)
- ◯ Overtime (>40 hours/wk)

14. Parenthood Status:

- ◯ No children (please skip to Health and Quality of Life Information (SF-36))
- ◯ 1 child
- ◯ 2 children
- ◯ 3 children
- ◯ Other (please specify):

15. Age of children (select all that apply):

- ☐ 0-5 years
- ☐ 5-7 years
- ☐ 8-10 years
- ☐ >10 years

Health Indicators:

16. In general, how would you rate your overall health?

- ◯ Excellent
- ◯ Very Good
- ◯ Good
- ◯ Fair
- ◯ Poor

17. How would you describe your smoking status (e.g., cigarettes, cigars, hookah/shisha)?

- ◯ Current smoker
- ◯ Past smoker
- ◯ Non-smoker

18. How often do you consume alcohol (i.e. standardized drink = 341ml (12oz) bottle of 5% alcohol beer, cider, cooler; 43ml (1.5oz) shot of 40% hard liquor (vodka, rum, whisky, gin); 142ml (5oz) glass of 12% wine)?

- ◯ > 2 drinks/day or at least 2 episodes of binge drinking in the last month (e.g., >4 drinks/2 hours, feeling "drunk")
- ◯ 1-2 drinks on most days of the week (e.g., 4-5 drinks/week at a pace of 1 drink/hour)
- ◯ 1-2 drinks/week or 4-8 drinks/month
- ◯ 1-2 drinks/month
- ◯ Never

20. Have you ever been diagnosed with any of the following health conditions? (Please select all that apply):

- ☐ Cardiovascular disease
- ☐ Cancer
- ☐ Pulmonary (lung) disease
- ☐ Hypertension (high blood pressure)
- ☐ Pre-diabetes or Type I/II Diabetes
- ☐ Other (please specify):
- ☐ Obesity/Overweight (e.g., BMI >25)
- ☐ Fibromyalgia, Chronic Fatigue Syndrome
- ☐ Auto-Immune Disorder
- ☐ None/Not Applicable

Do you experience chronic pain? (e.g., any persistent or recurrent pain lasting for 3-months or longer)

- ◯ Yes
- ◯ No

If YES, please indicate where in your body you experience chronic pain (e.g., upper right side of neck, lower abdomen, pelvic floor)

Mental Health Questions

21. **Are you currently** living with a mental health disorder that was clinically diagnosis by a licensed health professional (e.g., Psychiatrist)? (Select all that apply):

- [ ] Depressive Disorder
- [ ] Anxiety Disorder (generalized, social)
- [ ] Bipolar I/II
- [ ] Borderline Personality Disorder
- [ ] Schizophrenia/Schizoaffective
- [ ] Other (please specify)
- [ ] Posttraumatic Stress Disorder
- [ ] Substance Abuse/Addiction
- [ ] Self-Harm/Attempted Suicide
- [ ] None/Not Applicable

22. Are you **currently** taking any prescribed medications to treat a mental health disorder? (e.g., medical marijuana, anti-depressant medication (e.g., Zoloft, Prozac), anti-anxiety (e.g., Xanax, Ativan)

- ◯ Yes
- ◯ No

If yes, please specify the names of all current medications:

23. Have you ever abused prescription drugs (e.g., taken more than the prescribed dosage on purpose; used someone else's prescription drugs on purpose)?

- ◯ Yes
- ◯ No

24. Have you ever used drugs other than those required for medical reasons (e.g., Cocaine, Heroine, Ecstasy, MDM, etc.)?

- ◯ Yes
- ◯ No

25. Currently, can you get though the week without using recreational drugs?

- ◯ Yes
- ◯ No

28. Within the last month, have you received treatment for a mental health disorder by a licensed/registered health professional (e.g., Registered Psychologist, Social Worker, Psychotherapist, Psychiatrist)?

- ◯ Yes
- ◯ No

If yes, please specify all that apply:

- [ ] Registered Psychologist (e.g., Clinical Psychologist, Psychologist)
- [ ] Psychotherapist
- [ ] Psychiatrist (Dr./MD)
- [ ] Social Worker
- [ ] Other:

29. What types of treatment have you received in the past for a mental health disorder? Please select all that apply:

- [ ] Talk Therapy (e.g., Cognitive Behavioural Therapy (CBT))
- [ ] Hospitalization in a mental health unit or facility
- [ ] Eye Movement Desensitization and Reprocessing (EMDR)
- [ ] Complementary and alternative medicine (e.g., acupuncture, Traditional Chinese Medicine)
- [ ] Electroconvulsive therapy (ECT)
- [ ] Other (please specify):

30. Do you have a history of mental health disorders that run in your family? (e.g., first-degree relatives)?

- ◯ Yes
- ◯ No/Not Sure

Physical Health Questions

32. During the last week (7-days), how many planned scheduled sessions of at least 30-minutes moderate-vigorous exercise (e.g., sweating, increased heart rate) did you participate in (e.g., run/jog, spin class, strength training, elliptical/treadmill)?

- ◯ None/0 sessions
- ◯ 1 session
- ◯ 2-3 sessions
- ◯ 4-5 sessions
- ◯ >5 sessions

33. During the last week (7-days), how many **total minutes** of moderate-vigorous exercise (e.g., slight perspiration, increased heart rate) did you accumulate (e.g., spin class, gym, running)?

- ◯ None
- ◯ 0-30 minutes in the last week
- ◯ >30-60 minutes in the last week
- ◯ >60-90 minutes (>1-1.5 hrs) in the last week
- ◯ >90-120 minutes (>1.5-2 hrs) in the last week
- ◯ >120-150 minutes (>2-2.5hrs) in the last week
- ◯ >150 minutes (>2.5hrs) in the last week

35. In the last month, how many planned scheduled yoga classes of at least 60-minutes (e.g., Hot Yoga, Power Flow, Yin Yoga) did you participate in?

- ◯ None
- ◯ 1 yoga class
- ◯ 2-3 yoga classes
- ◯ 4-5 yoga classes
- ◯ >5 yoga classes

During the last month, how many planned scheduled sessions of 10-minutes of mindfulness meditation have you completed?

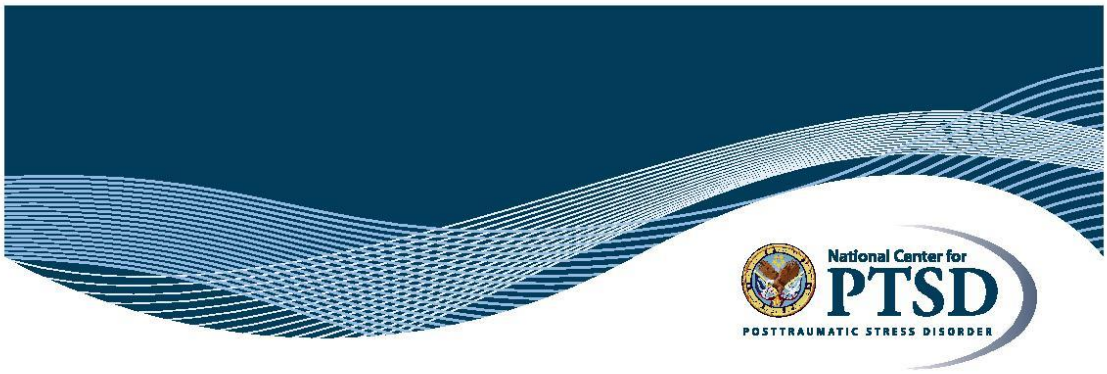
This survey asks for your views about your health, how you feel and how well you are able to do your usual activities. Answer every question by checking the appropriate response. There are no right or wrong answers. If you are unsure about how to answer a question, please give the best answer you can.

1. In general, would you say your health is:

Excellent	Very Good	Good	Fair	Poor
○	○	○	○	○

2. Compared to one year ago, how would you rate your health in general now?

Much better	Somewhat better	About the same	Somewhat worse	Much worse
○	○	○	○	○



The PTSD Checklist for *DSM-5*

Version date: 14 August 2013

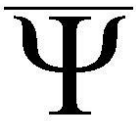
Reference: Weathers, F. W., Litz, B. T., Keane, T. M., Palmieri, P. A., Marx, B. P., & Schnurr, P. P. (2013). *The PTSD Checklist for DSM-5 (PCL-5) – Standard* [Measurement instrument]. Available from http://www.ptsd.va.gov/

URL: http://www.ptsd.va.gov/professional/assessment/adult-sr/ptsd-checklist.asp

PCL-5

Instructions: 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 the right to indicate how much you have been bothered by that problem in the past month.

In the past month, how much were you bothered by:	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
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



PCS-EN

Client No.: _____ Age: _____ Sex: M(__) F(__) Date: _____

Everyone experiences painful situations at some point in their lives. Such experiences may include headaches, tooth pain, joint or muscle pain. People are often exposed to situations that may cause pain such as illness, injury, dental procedures or surgery.

We are interested in the types of thoughts and feelings that you have when you are in pain. Listed below are thirteen statements describing different thoughts and feelings that may be associated with pain. Using the following scale, please indicate the degree to which you have these thoughts and feelings when you are experiencing pain.

0 – not at all **1** – to a slight degree **2** – to a moderate degree **3** – to a great degree **4** – all the time

When I'm in pain …

1. ☐ I worry all the time about whether the pain will end.
2. ☐ I feel I can't go on.
3. ☐ It's terrible and I think it's never going to get any better.
4. ☐ It's awful and I feel that it overwhelms me.
5. ☐ I feel I can't stand it anymore.
6. ☐ I become afraid that the pain will get worse.
7. ☐ I keep thinking of other painful events.
8. ☐ I anxiously want the pain to go away.
9. ☐ I can't seem to keep it out of my mind.
10. ☐ I keep thinking about how much it hurts.
11. ☐ I keep thinking about how badly I want the pain to stop.
12. ☐ There's nothing I can do to reduce the intensity of the pain.
13. ☐ I wonder whether something serious may happen.

… Total

Updated 11/11

1903

Date: ☐☐ / ☐☐ / ☐☐
(month) (day) (year)

Subject's Initials : _____

Study Subject #: ☐☐☐☐

PLEASE USE BLACK INK PEN

Study Name: _____

Protocol #: _____

PI: _____

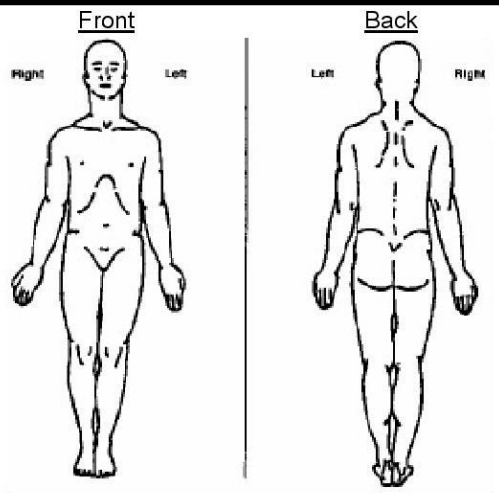
Revision: 07/01/05

Brief Pain Inventory (Short Form)

1. Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains, and toothaches). Have you had pain other than these everyday kinds of pain today?

☐ Yes ☐ No

2. On the diagram, shade in the areas where you feel pain. Put an X on the area that hurts the most.



3. Please rate your pain by marking the box beside the number that best describes your pain at its worst in the last 24 hours.

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

No Pain — Pain As Bad As You Can Imagine

4. Please rate your pain by marking the box beside the number that best describes your pain at its least in the last 24 hours.

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

No Pain — Pain As Bad As You Can Imagine

5. Please rate your pain by marking the box beside the number that best describes your pain on the average.

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

No Pain — Pain As Bad As You Can Imagine

6. Please rate your pain by marking the box beside the number that tells how much pain you have right now.

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

No Pain — Pain As Bad As You Can Imagine

1903

Date: (month) / (day) / (year)

Subject's Initials : _____

Study Subject #:

PLEASE USE BLACK INK PEN

Study Name: _____

Protocol #: _____

PI: _____

Revision: 07/01/05

7. What treatments or medications are you receiving for your pain?

8. In the last 24 hours, how much relief have pain treatments or medications provided? Please mark the box below the percentage that most shows how much relief you have received.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
☐ No Relief	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐ Complete Relief

9. Mark the box beside the number that describes how, during the past 24 hours, pain has interfered with your:

A. General Activity

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

B. Mood

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

C. Walking ability

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

D. Normal Work (includes both work outside the home and housework)

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

E. Relations with other people

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

F. Sleep

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

G. Enjoyment of life

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

Baseline Trauma-Informed Yoga RCT - Online Survey (MKC)

Beck's Depression Inventory

Instructions: This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the one statement in each group that best describes the way you have been feeling during the past two weeks, including today. Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

1. Sadness

I do not feel sad.	I feel sad much of the time.	I am sad all the time.	I am so sad or unhappy that I can't stand it.
○	○	○	○

2. Pessimism

I am not discouraged about my future.	I feel more discouraged about my future than I used to.	I do not expect things to work out for me.	I feel my future is hopeless and will only get worse.
○	○	○	○

3. Past Failure

I do not feel like a failure.	I have failed more than I should have.	As I look back on my life, I see a lot of failures.	I feel I am a total failure as a person.
○	○	○	○

4. Loss of Pleasure

I get as much pleasure as I ever did from the things I enjoy.	I don't enjoy things as much as I used to.	I get very little pleasure from the things I used to enjoy.	I can't get any pleasure from the things I used to enjoy.
○	○	○	○

5. Guilty Feelings

I don't feel particularly guilty	I feel guilty over many things I have done or should have done.	I feel quite guilty most of the time.	I feel guilty all of the time.
○	○	○	○

6. Punishment Feelings

I don't feel I am being punished.	I feel I may be punished.	I expect to be punished.	I feel I am being punished.
○	○	○	○

7. Self-Dislike

I feel the same about myself as ever.	I have lost confidence in myself.	I am disappointed in myself	I dislike myself.
○	○	○	○

8. Self-Criticism

I don't criticize or blame myself more than usual.	I am more critical of myself than I used to be.	I criticize myself for all of my faults.	I blame myself for everything bad that happens.
○	○	○	○

9. Suicidal Thoughts or Wishes

I don't have any thoughts of killing myself.	I have thoughts of killing myself, but I would not carry them out.	I would like to kill myself.	I would kill myself if I had the chance.
○	○	○	○

10. Crying

I don't cry any more than I used to.	I cry more now than I used to.	I cry over every little thing.	I used to cry, but now I can't cry even though I want to.
○	○	○	○

11. Agitation

I am no more restless or wound up than usual.	I feel more restless or wound up than usual.	I am so restless or agitated that it's hard to stay still.	I am so restless or agitated that I have to keep moving or doing something.
○	○	○	○

12. Loss of Interest

I have not lost interest in other people or activities.	I am less interested in other people or things than before.	I have lost most of my interest in other people or things.	It's hard to get interested in anything.
○	○	○	○

13. Indecisiveness

I make decisions about as well as I ever.	I find it more difficult to make decisions than usual.	I have much greater difficulty in making decisions more than I used to.	I have trouble making *any* decision.
○	○	○	○

14. Worthlessness

I do not feel I am worthless	I don't consider myself as worthwhile and useful as I used to.	I feel more worthless as compared to other people.	I feel utterly worthless.
○	○	○	○

15. Loss of Energy

I have as much energy as ever.	I have less energy than I used to have.	I don't have enough energy to do very much.	I don't have enough energy to do anything.
○	○	○	○

16. Sleeping Pattern (select the **one** answer that best describes your sleep)

I have not experienced any change in my sleeping pattern	I sleep **somewhat more** than usual.	I sleep **somewhat less** than usual.	I sleep **a lot more** than usual.	I sleep **a lot less** than usual.	I sleep most of the day.	I wake up 1-2 hours early and can't get back to sleep.
○	○	○	○	○	○	○

17. Irritability

I am no more irritable than usual.	I am more irritable than usual.	I am much more irritable than usual.	I am irritable all the time.
○	○	○	○

18. Changes in Appetite (Please select the **one** best answer that describes your appetite)

I have not experienced any change in my appetite.	My appetite is **somewhat less than** usual.	My appetite is **somewhat greater** than usual.	My appetite is **much less** than before.	My appetite is **much greater** than n usual.	I have no appetite at all.	I crave and eat food all the time.
○	○	○	○	○	○	○

19. Concentration Difficulty

I can concentrate as well as ever.	I can't concentrate as well as usual.	It's hard to keep my mind on anything for very long.	I find I can't concentrate on anything.
○	○	○	○

20. Tiredness or Fatigue

I am no more tired or fatigued than usual.	I get more tired or fatigued more easily than usual.	I am too tired or fatigued to do a lot of the things I used to do.	I am too tired or fatigued to do most of the things I used to do.
○	○	○	○

21. Loss of Interest in Sex

I have not noticed any recent change in my interest in sex.	I am less interested in sex than I used to be.	I am much less interested in sex now.	I have lost interest in sex completely.
○	○	○	○

25

Beck Anxiety Inventory (BAI)

Below is a list of 21 common symptoms of anxiety. Please carefully read each item in the list. Indicate how much you have been bothered by that symptom during the past month, including today, by selecting the **response that best describes you for each symptom.**

	Not At All	Mildly but it didn't bother me much	Moderately - it wasn't pleasant at times	Severely – it bothered me a lot
Numbness or tingling	○	○	○	○
Feeling hot	○	○	○	○
Wobbliness in legs	○	○	○	○
Unable to relax	○	○	○	○
Fear of worst happening	○	○	○	○
Dizzy or lightheaded	○	○	○	○
Heart pounding/racing	○	○	○	○
Unsteady	○	○	○	○
Terrified or afraid	○	○	○	○
Nervous	○	○	○	○
Feeling of choking	○	○	○	○
Hands trembling	○	○	○	○
Shaky / unsteady	○	○	○	○
Fear of losing control	○	○	○	○
Difficulty in breathing	○	○	○	○
Fear of dying	○	○	○	○
Scared	○	○	○	○
Indigestion	○	○	○	○
Faint / lightheaded	○	○	○	○
Face flushed	○	○	○	○
Hot/cold sweats	○	○	○	○

Baseline Trauma-Informed Yoga RCT - Online Survey (MKC)

Five Facet Mindfulness Questionnaire

Please rate each of the following 39 statements with the number that best describes your own opinion of what is generally true for you.

Please rate each of the following statements using the scale provided. Choose the answer that best describes your own opinion of what is generally true for you.

	Never or very rarely true	Rarely true	Sometimes true	Often true	Very often or always true
1. When I'm walking, I deliberately notice the sensations of my body moving.	○	○	○	○	○
2. I'm good at finding words to describe my feelings.	○	○	○	○	○
3. I criticize myself for having irrational or inappropriate emotions.	○	○	○	○	○
4. I perceive my feelings and emotions without having to react to them.	○	○	○	○	○
5. When I do things, my mind wanders off and I'm easily distracted.	○	○	○	○	○
6. When I take a shower or bath, I stay alert to the sensations of water on my body.	○	○	○	○	○
7. I can easily put my beliefs, opinions, and expectations into words.	○	○	○	○	○
8. I don't pay attention to what I'm doing because I'm daydreaming, worrying, or otherwise distracted.	○	○	○	○	○
9. I watch my feelings without getting lost in them.	○	○	○	○	○
10. I tell myself I shouldn't be feeling the way I'm feeling.	○	○	○	○	○

	Never or very rarely true	Rarely true	Sometimes true	Often true	Very often or always true
11. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions.	○	○	○	○	○
12. It's hard for me to find the words to describe what I'm thinking.	○	○	○	○	○
13. I am easily distracted.	○	○	○	○	○
14. I believe some of my thoughts are abnormal or bad and I shouldn't think that way.	○	○	○	○	○
15. I pay attention to sensations, such as the wind in my hair or sun on my face.	○	○	○	○	○
16. I have trouble thinking of the right words to express how I feel about things	○	○	○	○	○
17. I make judgments about whether my thoughts are good or bad.	○	○	○	○	○
18. I find it difficult to stay focused on what's happening in the present.	○	○	○	○	○
19. When I have distressing thoughts or images, I "step back" and am aware of the thought or image without getting taken over by it.	○	○	○	○	○
20. I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing.	○	○	○	○	○
21. In difficult situations, I can pause without immediately reacting.	○	○	○	○	○

	Never or very rarely true	Rarely true	Sometimes true	Often true	Very often or always true
22. When I have a sensation in my body, it's difficult for me to describe it because I can't find the right words.	○	○	○	○	○
23. It seems I am "running on automatic" without much awareness of what I'm doing.	○	○	○	○	○
24. When I have distressing thoughts or images, I feel calm soon after.	○	○	○	○	○
25. I tell myself that I shouldn't be thinking the way I'm thinking.	○	○	○	○	○
26. I notice the smells and aromas of things.	○	○	○	○	○
27. Even when I'm feeling terribly upset, I can find a way to put it into words.	○	○	○	○	○
28. I rush through activities without being really attentive to them.	○	○	○	○	○
29. When I have distressing thoughts or images I am able just to notice them without reacting.	○	○	○	○	○
30. I think some of my emotions are bad or inappropriate and I shouldn't feel them.	○	○	○	○	○
31. I notice visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow.	○	○	○	○	○
32. My natural tendency is to put my experiences into words.	○	○	○	○	○
33. When I have distressing thoughts or images, I just notice them and let them go.	○	○	○	○	○

	Never or very rarely true	Rarely true	Sometimes true	Often true	Very often or always true
34. I do jobs or tasks automatically without being aware of what I'm doing.	○	○	○	○	○
35. When I have distressing thoughts or images, I judge myself as good or bad, depending what the thought/image is about.	○	○	○	○	○
36. I pay attention to how my emotions affect my thoughts and behavior.	○	○	○	○	○
37. I can usually describe how I feel at the moment in considerable detail.	○	○	○	○	○
38. I find myself doing things without paying attention.	○	○	○	○	○
39. I disapprove of myself when I have irrational ideas.	○	○	○	○	○

Thank you for taking the time to complete our survey! Please click "Done".

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Post-Intervention Yoga for PTSD Follow-Up - Online Survey (MKC)

Clinical Trial Indicators

The next series of questions pertain to your participation in the 8-week Online Yoga & Mindfulness Randomized Controlled Trial. There are no right or wrong answers, please provide as honest and accurate answers as possible.

During a typical week (7-days), how many times on average did you watch/complete a **yoga video**?

During the last 7-days, please indicate how many total cumulative minutes did you spend doing **yoga** (e.g., twice for 20mins = **40 minutes**)?

Overall, out of the 8 weekly yoga videos, how many were you able to get through? (e.g., 0 = none of the videos to 8 = I watched each of the 8 videos)

During a typical week (7-days), how many times did you listen to a **guided meditation audio recording**?

During the last 7-days, please indicate how many total cumulative minutes you spent doing **guided mindfulness meditation** (e.g., three times for 10mins = **30 minutes total**)?

During a typical week (7-days), how many times did you practice a **breath technique** from the breath manual of at least 10-breath cycles (1-2mins)?

During the last 7-days, please indicate how many total cumulative minutes you spent doing **breathing techniques** (e.g., three times for 2mins = **6 minutes total**)?

Please indicate the typical time of day you accessed the online intervention resources/materials. (Select all that apply)

- [ ] Early Morning (e.g., 5am-9am)
- [ ] Morning (e.g., 9am - 12pm)
- [ ] Afternoon (e.g., 12pm-4pm)
- [ ] Early Evening (e.g., 4pm-7pm)
- [ ] Evening (e.g., 7pm-10pm)
- [ ] Late Evening/Bedtime (e.g., 10pm-12am)
- [ ] Middle of the Night (e.g., 12am-5am)

What weekly theme **most** resonated with you?

- ○ Session 1: Start Where You Are
- ○ Session 2: The Ebb & flow
- ○ Session 3: Your Body Has Your Back
- ○ Session 4: Emotional Imprint
- ○ Session 5: Embrace the Suffering
- ○ Session 6: The Second Arrow
- ○ Session 7: Towards Forgiveness
- ○ Session 8: Facing Forwards

Please rank the following components of the intervention from 1-6 with the follow scale **1 = <u>most</u> valuable/helpful** and 6 **= <u>least</u> valuable/helpful**

Weekly Health Coach Calls

Weekly Email Summaries from the Health Coach

Online Weekly Yoga Videos

Weekly Live-Streamed Guided Yoga/Meditation Sessions

Online Guided Meditation Audio Recordings

Online Resources Page on the Website

As a result of participating in the 8-week Online Yoga and Mindfulness Randomized Controlled Trial Research Study, please consider each of the intervention components. Please rate how helpful or unhelpful each of the components were by selecting the appropriate response. If you did not access one of the components, please select "N/A"

	Extremely Unhelpful	Somewhat Unhelpful	Neutral	Somewhat Helpful	Extremely Helpful	N/A
Weekly Health Coach Calls	○	○	○	○	○	○
Weekly Written Email Summary from my Health Coach	○	○	○	○	○	○
Online Weekly Yoga Videos (e.g., Session 1: Start Where You Are)	○	○	○	○	○	○
Weekly Live-Streamed Guided Meditation Sessions (e.g., online live meditation sessions via zoom.us)	○	○	○	○	○	○
Daily Guided Meditation Audio Recordings (e.g., Take 5 Breaths, Body Scan, Mindful Listening)	○	○	○	○	○	○
Online "My Favourite Resources" Page (e.g., Podcasts, TEDTalks, #TheMindfulMinute)	○	○	○	○	○	○
24/7 Access to Resources and Materials	○	○	○	○	○	○
www.healmytraumaimprint.com website overall	○	○	○	○	○	○

As a result of participating in the 8-week Online Yoga and Mindfulness Randomized Controlled Trial Research Study, please consider the last 8-weeks as you respond to the following questions. Read each statement and then select the appropriate response.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Overall, I believe the severity of my PTSD symptoms **reduced**	○	○	○	○	○
Overall, I **feel better than when I started**	○	○	○	○	○
Overall, I see **an improvement in my health and wellbeing**	○	○	○	○	○
Overall, I have a **better understanding** how yoga and mindfulness can help alleviate symptoms of PTSD	○	○	○	○	○
Overall, I **enjoyed participating**	○	○	○	○	○
Overall, I found the online yoga and mindfulness randomized controlled trial **helpful**	○	○	○	○	○
Overall, I got **value** out of participating	○	○	○	○	○
Overall, I **learned something new** about healing from PTSD that I previously did not know	○	○	○	○	○
Overall, I am **satisfied with my experience** participating	○	○	○	○	○
Overall, I would **participate again**	○	○	○	○	○

Please provide any additional constructive feedback, comments, or suggestions that you think would be helpful to enhance the Online Yoga and Mindfulness Randomized Controlled Trial for future participants.

Thank you for taking the time to participate in our research study!

Appendix E: IAPS Normative Valence and Arousal Scores for the 60 Images Selected for the Emotional Image Stress Task Experiment

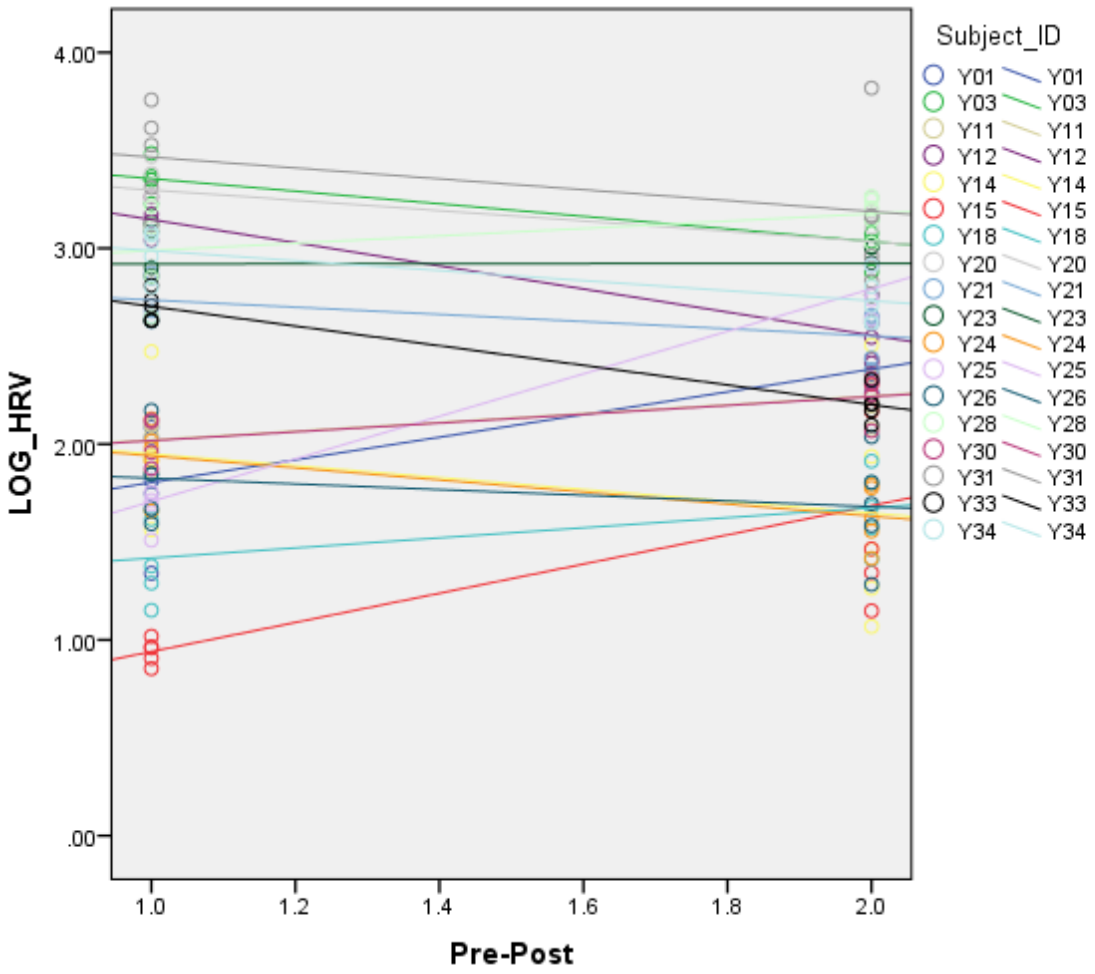
IAPS ID	Valence *M*	Valence SD	Arousal *M*	Arousal SD	Description
1111	3.25	1.64	5.2	2.25	Snake
1120	3.79	1.93	6.93	1.68	Snake
1201	3.55	1.88	6.36	2.11	Spider
1202	3.35	1.77	5.94	2.17	Spider
1300	3.55	1.78	6.79	1.84	Angry Dog
1930	3.79	1.92	6.42	2.07	Shark
2095	1.79	1.18	5.25	2.34	Toddler
2120	3.34	1.91	5.18	2.52	Angry Male Face
2130	4.08	1.33	5.02	2.00	Angry Female Face
2141	2.44	1.64	5.00	2.03	Grieving Family
2301	2.78	1.38	4.57	1.96	Kid Crying
2312	3.71	1.64	4.02	1.66	Mother
2345.1	2.26	1.46	5.50	2.34	Black Eye
2455	2.96	1.79	4.46	2.12	Sad Girls
2525	4.06	1.93	3.93	2.16	Women
2682	3.69	1.65	4.48	2.1	Police
2683	2.62	1.78	6.21	2.15	War
2688	2.73	2.07	5.98	2.22	Hunters
2691	3.04	1.73	5.85	2.03	Riot
2694	3.55	1.72	5.05	2.16	Police
2695	4.01	1.58	4.47	1.92	Refugees
2703	1.91	1.26	5.78	2.25	Sad Children
2710	2.52	1.69	5.46	2.29	Drug Addict
2718	3.65	1.58	4.46	2.03	Drug Addict
2745.2	3.91	2.00	5.17	2.14	Shoplifter
2751	2.67	1.87	5.18	2.39	Drunk Driver
2752	4.07	1.84	4.3	1.94	Alcoholic
2810	4.31	1.65	4.47	1.92	Boy
2900	2.45	1.42	5.09	2.15	Crying Boy
3103	2.07	1.27	6.06	2.3	Injured legs
3185	2.81	1.52	5.48	2.18	Stiches
3022	3.7	1.91	5.88	2.08	Scream
3211	4.15	1.91	5.72	1.94	Surgery
3213	2.96	1.94	6.82	2.00	Surgery
3216	3.28	1.64	5.37	2.00	Medical Assist
3301	1.8	1.28	5.21	2.26	Injured Child
4621	3.19	1.59	4.92	2.24	Harassment
5940	4.23	1.68	6.29	1.85	Lava
5961	3.52	1.86	5.80	2.37	Tornado

6000	4.04	1.74	4.91	2.17	Prison
6190	3.57	1.84	5.64	2.03	Aimed Gun
6312	2.48	1.52	6.37	2.30	Abduction
6530	2.76	1.86	6.18	2.02	Attack
6821	2.38	1.72	6.29	2.02	Gang
7380	2.46	1.42	5.88	2.44	Roach on Pizza
9041	2.98	1.58	4.64	2.26	Scared Child
9050	2.43	1.61	6.36	1.97	Plane Crash
9187	1.81	1.36	6.45	2.3	Injured Dog
9220	2.06	1.54	4.00	2.09	Cemetery
9250	2.57	1.39	6.6	1.87	War Victim
9325	1.89	1.23	6.01	2.54	Vomit
9424	2.87	1.62	5.78	2.12	Bomb
9428	2.31	1.31	5.66	2.41	Assault
9584	3.34	1.57	4.96	2.15	Dental Exam
9594	3.76	1.70	5.17	2.17	Injection
9600	2.48	1.62	6.46	2.31	Ship Sink
9910	2.55	1.42	5.93	2.10	Car Accident
9921	2.04	1.47	6.52	1.94	Fire
9925	2.84	1.35	5.59	2.23	Fire
9926	3.85	1.59	4.83	1.95	Flood
60 images	3.05	1.63	5.51	2.13	

Appendix F: Descriptive Statistics of Raw Electrocardiography (ECG) Data Output for PTSD Participants at Baseline (n = 18) and Post-Intervention (n = 18)

	PTSD T1 (*n* = 18)	PTSD T2 (*n* = 18)	Non-PTSD Sample (n=46)
Variable	***M(SD)***	***M(SD)***	***M(SD)***
	86.43(13.98)	84.95(10.76)	76.45(11.09)
	86.84(13.59)	82.72(9.80)	75.14(10.61)
HR(bpm)	85.79(12.62	82.67(9.43)	76.08(11.02)
	85.46(13.69)	83.86(10.05)	76.52(10.78)
	86.57(14.04)	84.88(9.43)	78.27(11.50)
	16.32(4.09)	16.30(4.48)	16.92(2.72)
	16.34(4.811	16.57(4.97)	16.71(2.74)
Respiration(b/min)	16.57(4.81)	16.55(4.82)	16.67(2.87)
	14.11(3.94)	14.03(4.25)	15.28(2.67)
	13.82(4.16)	13.86(4.30)	15.48(3.83)
	714.38(117.10)	718.84(86.04)	804.89(116.65)
	711.33(117.32)	737.83(87.24)	818.87(118.48)
Avg. RR(ms)	717.56(112.33)	737.36(83.43)	809.23(120.24)
	723.63(117.93)	729.46(87.63)	805.15(114.71)
	715.44(120.50)	718.53(79.91)	788.36(118.31)
	30.89(26.02)	30.14(19.54)	49.04(25.69)
	34.17(27.73)	29.80(17.00)	53.96(31.25)
RMSSD(ms)	30.95(24.27)	29.50(16.85)	48.64(25.52)
	32.85(20.72)	32.97(21.58)	53.17(24.24)
	34.43(23.92)	27.95(15.79)	50.93(22.69)
	309.67(317.41)	451.70(527.98)	781.28(1019.51)
	462.63(495.80)	454.35(454.53)	774.40(1128.10)
VLF HRV(ms^2)	536.74(678.75)	469.33(497.31)	949.12(1079.65)
	613.77(599.54)	513.96(411.05)	938.02(852.72)
	540.35(561.42)	452.73(387.59)	990.84(889.12)
	937.13(1642.05)	751.80(961.05)	824.47(718.64)
	982.93(1306.80)	1195.99(2009.07)	1013.86(791.46)
LF HRV(ms^2)	950.12(1189.60)	1248.66(1746.24)	1064.29(795.37)
	1792.06(2114.65)	2104.44(3057.85)	1727.46(1523.68)
	2235.40(2829.94)	1695.70(2811.43)	1827.45(1777.16)
	708.05(954.41)	559.79(624.17)	1467.45(1649.49)
	995.50(1463.33)	490.12(556.77)	1827.16(21.07.07)
HF HRV(ms^2)	810.08(1123.87)	460.78(438.11)	1446.24(1577.96)
	774.59(881.84)	810.19(1515.71)	1547.99(1476.85)
	580.94(621.15)	408.61(361.91)	1257.99(1208.05)
	1.84(1.30)	2.87(4.08)	1.43(2.01)
	1.86(1.50)	2.27(1.60)	1.17(1.37)
LF/HF Ratio	2.45(3.07)	3.15(2.49)	1.39(1.33)
	2.89(1.35)	3.25(2.17)	2.03(2.44)
	3.75(4.03)	3.23(2.29)	2.63(2.84)

Appendix G: Scatterplot graph of HF HRV from Pre to Post Intervention among PTSD Participants



Appendix H: Intention to Treat Descriptive Statistics of HF HRV during Protocol Conditions for PTSD Participants at Baseline (n = 22) and at Post-Intervention (n = 18)

Time Period	**PTSD T1 (*n* = 22)**			**PTSD T2 (*n* = 18)**			
Protocol Phase	***EMM(SE)***	***Log10(SE)***	***Missing n***	***EMM(SE)***	***Log10(SE)***	***Missing n***	***p*[s]**
BL Rest Phase	620.69(*183.47*)	2.31(0.15)	0	559.79(*142.97*)	2.31(*0.18*)	4	*ns*
ES1 (0-5min)	858.38(*280.68*)	2.44(0.15)	0	490.12(*127.53*)	2.40(*0.13*)	4	*ns*
ES2 (5-10min)	727.32(*214.20*)	2.42(0.15)	0	460.78(*100.36*)	2.38(*0.14*)	4	*ns*
GM1 (0-5min)	693.00(*169.95*)	2.45(0.14)	0	810.19(*347.19*)	2.50(*0.14*)	4	*ns*
GM2 (5-10min)	536.29(*122.25*)	2.41(0.13)	1	408.61(*85.16*)	2.44(*0.10*)	5	*ns*
BL HR (bpm)	87.07(3.21)		0	84.32(2.61)		0	*ns*

Note. P[s] = pairwise comparisons using Bonferroni correction; [a]mean differences between T1 and T2 explains where interaction effect would occur with larger sample size; EMM = Estimated Marginal Means; SE = Standard Error

Appendix I: Exploratory Pupil Response Measures

Table 32

Average pupil dilation response during 500 ms, 1 s, and 10 s epochs across a 25-minute protocol of rest, stress, and guided meditation

	PTSD T1					***PTSD T2***					***Non-PTSD***				
Epoch	BL	ES1	ES2	GM1	GM2	BL	ES1	ES2	GM1	GM2	BL	ES1	ES2	GM1	GM2
500ms	0.01(.05)	0.16(.09)	0.11(.10)	-0.01(.08)	-0.08(.10)	-0.02(.07)	**0.05(.09)^**	**0.03(.10)^**	**-0.06(.08)**	-0.13(.08)	**-0.04(.06)^**	0.10(.11)	0.05(.13)	**-0.09(.09)^**	-0.14(.09)
1s	-0.01(.05)	0.15(.09)	0.12(.10)	-0.03(.07)	-0.08(.10)	**-0.04(.06)***	**0.05(.10)^**	**0.03(.10)^**	**-0.08(.07)***	-0.13(.07)	**-0.06(.05)^**	0.09(.11)	0.05(.13)	**-0.10(.08)^**	-0.14(.09)
10s	-0.01(.05)	0.17(.10)	0.15(.10)	-0.00(.08)	-0.06(.10)	**-0.04(.06)***	**0.07(.09)^**	**0.06(.10)^**	**-0.05(.08)***	-0.10(.07)	**-0.06(.05)^**	0.11(.10)	0.07(.13)	**-0.07(.09)***	-0.11(.09)

***Note. *p < .05; ^p < .01* compared to PTSD T1.** All values are average relative pupil dilation measures (0.10 = 10%). BL = baseline rest phase; ES = emotional image stress phase; GM = guided meditation phase