Just Breathe:

Dynamic Breathwork as Interoceptive Exposure for Veterans and Police

A thesis

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Ben Pointer

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Abstract

Military veterans and police officers experience high rates of trauma-related symptoms alongside autonomic dysregulation, yet many do not engage with or complete conventional therapies. Breathing-based interventions may provide a low-cost, acceptable alternative. I used a single-subject, multiple-baseline-across-participants design with eight veterans and police officers to evaluate a 10-session online dynamic breathwork protocol. I hypothesised that this intervention would (H1) increase resting heart rate variability (HRV) and reduce resting heart rate, (H2) improve self-reported psychological symptoms commonly associated with PTSD, and (H3) be rated as acceptable and feasible for home-based use. Participants practiced cyclic hyperventilation, extended breath-holds, and a Valsalva-type manoeuvre in 10 sessions across a 20-day period. Resting heart rate variability (RMSSD) and heart rate were recorded daily with Polar® H10 sensors. Self-reported psychological measures of depression, anxiety, affect, mindfulness, and psychological flexibility were completed at baseline, post-intervention, and follow-up. Physiological outcomes did not show meaningful change. However, large effect sizes were observed across all psychological measures, with reductions in self-reported scores of depression, anxiety, and negative affect, and increases in mindful awareness and psychological flexibility. Social validity ratings indicated that the protocol was highly acceptable and feasible for home use. In contrast to traditional exposure therapies that target external trauma cues, this intervention employed breath-based interoceptive exposure to engage conditioned internal responses, offering a novel pathway for inhibitory learning. My results suggest that while short-term autonomic adaptation was not evident, structured online breathwork may offer a promising and scalable means of reducing psychological distress for trauma-exposed operational personnel.

Keywords: breathwork, heart rate variability, interoceptive exposure, police, single-case design, trauma, veterans

Acknowledgements

"He aha te mea nui o te ao? He tangata, he tangata, he tangata"

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To the eight veterans and police officers who took part in this study: your willingness to show up, day after day, often in the face of your own personal challenges, is an act of courage. Your dedication reflects the strength of character that defines those who serve. Your commitment has already helped to shape effective pathways of support for others.

To my partner and my son: thank you for your love, patience, and for walking beside me on this journey. You have given me strength when I was tired, perspective when I was lost in my work, and joy when I needed it most. This achievement is as much yours as it is mine.

Finally, I dedicate this thesis to the veterans and police officers we have lost. Over the last year, more than 250 UK veterans and police officers took their own lives. May this contribution stand as a reminder that their lives mattered, as a tribute to their memory, and as a call to continue seeking better ways to support those who have given so much.

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Just Breathe: Dynamic Breathwork as Interoceptive Exposure for Veterans and Police

For many military veterans, the impact of service does not end with deployment; it follows them home. Rates of post-traumatic stress disorder (PTSD) are significantly higher amongst veterans than the general population, impairing sleep, cognition, and quality of life (Gates et al., 2012). Police officers, though serving in a different capacity, face persistent strain from repeated exposure to trauma and high-pressure situations. Their prevalence of PTSD, depression, and substance misuse is comparable to that of veterans (Syed et al., 2022).

Despite differences in role, both groups carry the invisible wounds of occupational stress long after leaving service (Mobbs & Bonanno, 2018). Beneath these shared struggles lies a deeper pattern of autonomic dysregulation and behavioural rigidity (Ge et al., 2020; Ley, 2001). Reduced heart rate variability (HRV) reflects the body's diminished capacity to shift flexibly between stress and recovery (Ge et al., 2020), while avoidance behaviours reinforce hypervigilance and withdrawal, sustaining symptoms over time (Hofmann & Hay, 2018; Ley, 2001). These processes also contribute to the high comorbidity of PTSD with anxiety, depression, mood disorders, and psychological rigidity compounding the burden faced by this population (Rytwinski et al., 2013; Syed et al., 2022).

In this thesis, I examined how trauma shapes both physiology and behaviour, why conventional treatments often fall short, and whether structured breathwork can offer a practical, accessible alternative for those most at risk.

Prevalence rates for veterans

Mental health difficulties are common amongst veterans globally. In the UK, approximately 28% of serving and ex-serving personnel report a common mental disorder with 9% meeting criteria for PTSD and 8% for alcohol misuse (Sharp et al., 2024). Comparable findings have been observed elsewhere: prevalence estimates for PTSD range

from 11% to 30% across U.S. veteran samples (Müller et al., 2017; Schuman et al., 2022), 7.2% with Canadian veterans, and 12% with Australian veterans (Richardson et al., 2010).

PTSD rarely occurs in isolation. Comorbid conditions such as traumatic brain injury, substance use disorders, and interpersonal violence, can exacerbate distress and reduce quality of life for veterans and their families (Sullivan et al., 2019). Periods of transition, including post-deployment reintegration or leaving military service, may not themselves constitute psychiatric disorders but act as critical stressors that heighten vulnerability. These stressors are associated with poorer health outcomes including cardiovascular disease, obesity, interpersonal strain, difficulties reintegrating into civilian life, and increased risk of suicide (Mobbs & Bonanno, 2018; Ravindran et al., 2020; Ryder, 2018).

Despite the high prevalence and impact of PTSD and comorbidities, many veterans struggle to access effective care. Stigma, confidentiality concerns, mismatched services, and logistical barriers often deter individuals from seeking treatment (Hoerster et al., 2019; Mobbs & Bonanno, 2018; Ravindran et al., 2020; Ryder et al., 2018). Such barriers highlight a need for acceptable, accessible interventions that can reach those who might otherwise avoid traditional services.

Prevalence rates for police

Police officers also experience disproportionately high rates of mental health problems compared to the general population. A meta-analysis by Syed et al. (2022) estimated pooled prevalence rates of 14.2% for PTSD, 14.6% for depression, and 25.7% for hazardous drinking. Unlike veterans whose trauma exposure often stems from discrete deployments or combat events, police officers are subjected to recurrent and cumulative trauma across their careers. Kaufmann et al. (2013) found that such exposures were associated with elevated rates of mood and alcohol-use disorders, particularly amongst early-career officers. Supporting this, Liberman et al. (2002) reported that younger officers were

more vulnerable to distress, highlighting a need for targeted early interventions at the start of service. Importantly, Maguen et al. (2009) and Liberman et al. (2002) found that chronic occupational stressors such as workload pressures, poor managerial support, organisational inefficiencies, and workplace discrimination, predicted mental health problems more strongly, and occurred more often, than exposure to critical incidents. The results from both studies indicated that organisational factors more reliably predicted outcomes such as depression, anxiety, and functional impairment than trauma exposure itself.

When compared to veterans, police officers show broadly similar PTSD prevalence (~11–30% in veterans vs. ~14% in police; Schuman et al., 2022; Syed et al., 2022), but their risk pathways differ. Military personnel often confront acute, time-bound combat trauma, whereas police are more frequently exposed to ongoing interpersonal trauma (e.g., domestic violence, child abuse investigations) compounded by chronic organisational stressors. These structural and experiential differences may explain the distinct emergence of C-PTSD within policing roles (Steel et al., 2021).

Whilst my study included validated measures of depression, anxiety, mood, mindfulness, and psychological flexibility, a formal PTSD diagnostic scale was deliberately avoided. Prior research has shown that a PTSD label can pathologize adaptive responses to trauma and reduce individuals to a diagnosis (Elliott et al., 2018). Amongst veterans, PTSD assessments are often experienced as stigmatising, deter engagement to treatment, and reinforce avoidance behaviours (Lewis et al., 2022; Mittal et al., 2013).

PTSD and comorbidities

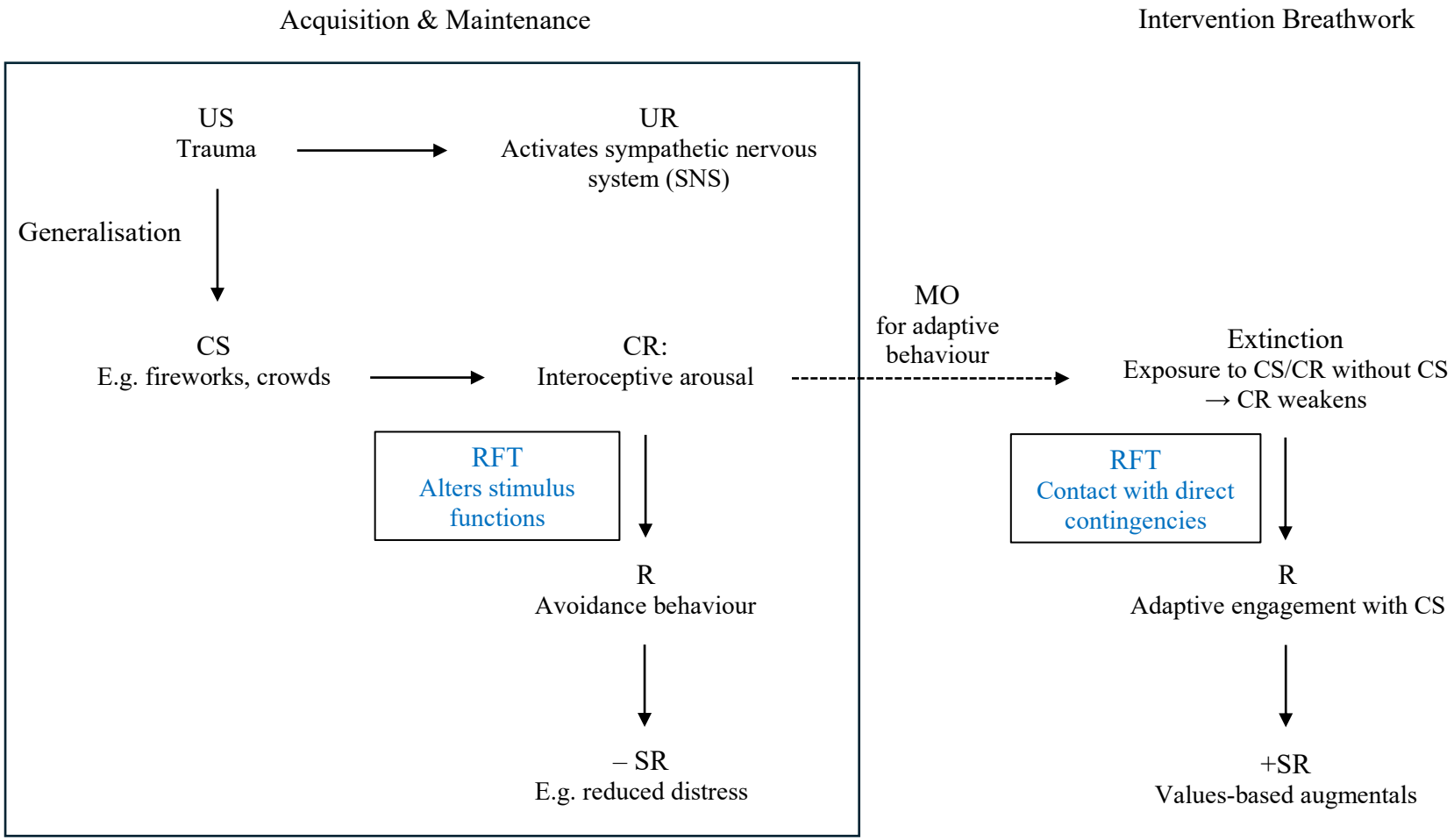
Acquisition and maintenance of symptoms in PTSD can be understood as maladaptive behavioural responses sustained through classical and operant conditioning processes. From this perspective, neutral stimuli associated with the traumatic event acquire the capacity to trigger and maintain symptoms long after the original episode (Lissek & van Meurs, 2015).

As illustrated in the left panel of Figure 1, traumatic events act as unconditioned stimuli (US), eliciting unconditioned responses (UR) such as activation of the sympathetic nervous system (SNS), and fight–flight reactions (Foa et al., 1989). Neutral cues present at the time of trauma may later become conditioned stimuli (CS), which can elicit conditioned responses (CR) similar to the UR, including interoceptive arousal (e.g., racing heart, breathlessness, dizziness), even in the absence of the US. Through stimulus generalisation, perceptually similar cues to those present during an event (e.g., fireworks, smells, crowded places) may also elicit these same conditioned responses, broadening the range of trauma-linked situations (Foa et al., 1989; Kreutzmann et al., 2021).

Reinforcement, punishment, and stimulus generalisation often maintain trauma symptoms. Interoceptive arousal (CR) can also be conceptualised as a conditioned motivating operation–reflexive (CMO-R), signalling the potential for further aversive stimulation. In this way, trauma-linked interoceptive cues both evoke sensations (e.g., racing heart, dizziness) and potentiate avoidance repertoires, increasing the likelihood that trauma-associated cues exert discriminative control (Edwards et al., 2019). The operant responses (R) to this arousal are typically avoidance behaviours, a central feature of PTSD, such as withdrawal from daily activities or substance abuse (Craske et al., 2008; Ley, 1999). These behaviours are maintained through negative reinforcement (–SR), which can temporarily reduce distress but entrench avoidance patterns and prevent extinction (Foa et al., 1989).

Figure 1

Behavioural Model of Trauma Responses and Intervention Pathway



Note. US = unconditioned stimulus; UR = unconditioned response; CS = conditioned stimulus; CR = conditioned response; CMO-R = conditioned motivating operation–reflexive; R = Response; RFT = relational frame theory; -/+ SR = negative/positive reinforcement.

Punishment also contributes to maintenance of trauma symptoms; adaptive behaviours (e.g., social interaction) may be suppressed when followed by aversive interoceptive responses (CR) such as dizziness, breathlessness, or surges in heart rate, which can signal an escalation of threat (Hayes et al., 1996; Ley, 2001).

Beyond direct conditioning, language can also amplify and maintain trauma responses, a viewpoint offered by Relational Frame Theory (RFT). Cognitive fusion and rigid rule-governed behaviour transform verbal statements (e.g., “I am broken,” “I have PTSD”) into inflexible avoidance rules that increase the likelihood of escape or withdrawal (Blackledge, 2004). Through derived relational responding, neutral contexts (e.g., crowds, supermarkets), or even thoughts, may acquire threat functions, evoking interoceptive arousal despite the absence of danger (Mulhern, 2022). Experiential avoidance, suppressing or escaping trauma-related thoughts and sensations, provides temporary relief but may block extinction learning and undermine psychological flexibility (Hayes et al., 1996). These processes alter the functional properties of both external cues and interoceptive states, further amplifying avoidance and maintaining maladaptive behaviours.

Current treatments

PTSD is typically treated with evidence-based therapies such as cognitive behavioural therapy (CBT), exposure therapy (ET), eye movement desensitisation and reprocessing (EMDR), cognitive processing therapy (CPT), and trauma-focused CBT, often alongside pharmacological interventions. While effective for some, veterans benefit less than civilians: dropout rates are high, with many disengaging with treatment before completion (Haagen et al., 2015; Schuman et al., 2022). Avoidance behaviours that define PTSD may contribute to withdrawal, while some veterans report being re-traumatised during narrative-based treatments or in vivo exposure. Direct confrontation with conditioned stimuli can elicit conditioned responses resembling the original unconditioned response (Craske et al., 2008;

Foa et al., 1989). These interventions are often resource-intensive, requiring significant time and in-person engagement (Schuman et al., 2022).

Pharmacological treatments provide only partial relief. Side effects are common, and many completers still experience residual symptoms: 31% continue to meet diagnostic criteria, while 59% report subthreshold hyperarousal (Larsen et al., 2019). Rates of treatment-resistant depression (TRD) are also high, with 68% of veterans in one psychiatric sample meeting TRD criteria with only 25% receiving adequate care (Allen & Bray, 2022).

Police officers face similar challenges. Stigma, confidentiality concerns, and fears of career repercussions can reduce help-seeking, with greater symptom severity predicting lower engagement with support services (Liberman et al., 2002; Steel et al., 2021). Together, these findings highlight the need for interventions that are less reliant on trauma narration, more accessible, and more acceptable to avoidance-prone groups by focusing on conditioned responses rather than trauma cues (Craske et al., 1997, 2008; Edwards-Stewart et al., 2021).

Breathwork offers an intervention pathway that targets autonomic dysregulation (Figure 1, right panel). Controlled exposure to interoceptive cues can recontextualise sensations that otherwise trigger hyperarousal, reduce avoidance, and increase tolerance (Craske et al., 1997; Kox et al., 2014; Schneider & Schwerdtfeger, 2020). Behaviourally, interoceptive cues ordinarily function as a CMO-R that potentiates avoidance. However, in the context of breathwork, those same cues may come to operate as motivating operations (MO) for adaptive responding (Edwards et al., 2019). When paired with values-based goals, such interventions can generate augmentals (verbal processes that alter the reinforcing value of adaptive behaviours). These augmentals increase the probability of continued responding in the face of aversive arousal and promote patterns of behaviour governed by long-term contingencies rather than immediate escape or avoidance. In this way, breathwork can be understood both as operant reinforcement of adaptive behaviour, and as a physiological

practice that enhances parasympathetic tone and supports transitions between arousal and recovery (Ley, 1999, 2001; Schuman et al., 2023).

Evidence also supports breathwork as a low-cost, scalable intervention. Meta-analyses found significant reductions in stress, anxiety, and depression, with many protocols delivered remotely or self-guided (Fincham, Strauss, et al., 2023; Morgan et al., 2024). Brief daily practice has been shown to improve mood and reduce arousal more effectively than mindfulness (Balban et al., 2023), while veteran-focused programmes reported sustained reductions in PTSD and depression (Colgan et al., 2015; Seppälä et al., 2014).

Although high-ventilation techniques remain under-studied, early work, including by Kox et al. (2014), suggests that dynamic breathwork may enable voluntary modulation of autonomic responses while eliciting interoceptive cues such as breathlessness and increased heart rate (Craske et al., 1997; Ley, 1999). This approach may offer an alternative for operational personnel reluctant to engage in traditional therapies.

Physiological measures of stress states

Operational personnel frequently display physiological stress states linked to PTSD including chronic interoceptive arousal and autonomic dysregulation. These are objectively indexed by heart rate and HRV which reflect autonomic function and the body's capacity to regulate stress (Schneider & Schwerdtfeger, 2020).

Resting heart rate provides a simple, non-invasive marker of stress and recovery. Elevated heart rate is commonly associated with exertion or psychological strain, while lower heart rate indicates more efficient cardiovascular regulation. However, heart rate alone does not capture the dynamic capacity for stress recovery which is more directly indexed by HRV. HRV represents the variability between successive heartbeats, reflecting the balance between sympathetic and parasympathetic activity (Shaffer & Ginsberg, 2017). Higher HRV generally indicates autonomic resilience and greater emotional and behavioural regulation, while

reduced HRV is associated with symptoms of PTSD, anxiety, and depression (Farhan et al., 2023; Immanuel et al., 2023; Shaffer et al., 2014).

The root mean square of successive differences (RMSSD) is a widely used time-domain HRV metric and serves as a robust indicator of parasympathetic tone (Shaffer & Ginsberg, 2017). Reduced RMSSD is a consistent finding for those diagnosed with PTSD and depression, reflecting diminished vagal control (Koch et al., 2019). For this reason, I selected RMSSD as the primary physiological outcome in my study. Although debates remain over optimal recording duration and posture, methodological consistency is considered more important than any single protocol (Buchheit, 2014; Nuuttila et al., 2022).

Beyond physiology, HRV has important behavioural implications. According to the neurovisceral integration model, higher HRV supports adaptive responses to stressors, including greater tolerance for discomfort, reduced avoidance, and improved decision-making under uncertainty (Forte, Morelli, et al., 2022; Forte, Troisi, et al., 2022; Thayer & Lane, 2000). In this way, HRV provides not only an objective biomarker of autonomic regulation but also a window into behavioural flexibility and self-regulation for trauma-exposed populations.

How breathing affects HRV

Breathing modulates HRV through both mechanical and chemical pathways, reflecting the body's capacity to regulate stress and adapt to environmental demands (Balzarotti et al., 2017; Boyadzhieva & Kayhan, 2021).

Mechanically, changes in intrathoracic pressure during inhalation and exhalation influence baroreceptor activity and vagal output, producing respiratory sinus arrhythmia (RSA), the rhythmic heart rate fluctuations across the breathing cycle. RSA is a key index of parasympathetic regulation and underlies much of the variability observed in HRV (Lehrer et al., 2000; Schuman et al., 2022).

Chemically, breathing alters carbon dioxide (CO_2) levels, which are monitored by brainstem chemoreceptors that drive autonomic adjustments. Slow-paced breathing preserves CO_2 homeostasis, enhances parasympathetic activity, and increases HRV. By contrast, hyperventilation reduces CO_2 (hypocapnia), shifting autonomic balance toward sympathetic dominance, reducing HRV, while prolonged breath-holding can initially enhance vagal rebound yet also activate sympathetic stress responses under hypoxia (Balban et al., 2023; Bourdas et al., 2024; Russo et al., 2017). Together, mechanical and chemical processes help explain why breathing practices directly influence autonomic function and emotional regulation.

Neural control

Breathing is unique among motor behaviours because it is governed by both autonomic and voluntary systems. Involuntary breathing rhythms are generated in the brainstem, particularly the preBötzinger Complex (preBötC) in the medulla, while voluntary control engages higher cortical structures including the motor cortex, insula, and prefrontal regions (Ashhad et al., 2022; Herrero et al., 2018; McKay et al., 2003). Rather than bypassing the brainstem, voluntary breathing integrates cortical and subcortical networks with brainstem centres, linking conscious control to autonomic regulation (Herrero et al., 2018). Voluntary breath control has been shown to modulate activity across emotional and cognitive systems, including the hippocampus and amygdala, enhancing connectivity between sensory and regulatory networks (Herrero et al., 2018). This mechanism may help explain the effectiveness of breath-focused practices for reducing stress and promoting emotional regulation. However, chronic stressors can disrupt this balance, leading to maladaptive breathing patterns and associated cognitive impairments (Boyadzhieva & Kayhan, 2021). Training voluntary breath control therefore represents a potential pathway for restoring autonomic adaptability, helping to shape adaptive behavioural repertoires.

Stress and autonomic dysregulation

PTSD symptoms such as hyperarousal, avoidance, and intrusive memories are closely tied to chronic activation of the body's stress response. Persistent sympathetic dominance and reduced parasympathetic activity can lead to autonomic dysregulation, typically indexed by diminished HRV (Ge et al., 2020; Tan et al., 2013). This physiological rigidity not only maintains PTSD symptoms but also contributes to comorbid anxiety and depression (Ge et al., 2020). Interventions that modulate HRV such as breathwork, may help restore autonomic flexibility and reduce hyperarousal (Balban et al., 2023; Fincham, Katar, et al., 2023). Autonomic dysregulation is reinforced when trauma-related cues activate the amygdala and hypothalamic stress pathways, heightening arousal and constraining behavioural flexibility (Ge et al., 2020). Over time, repeated activation contributes to maladaptive breathing patterns such as rapid shallow breathing or hyperventilation (>15–20 breaths per minute), which reduce CO_2 (hypocapnia) and trigger symptoms like dizziness, tingling, and heightened arousal (Fincham, Katar, et al., 2023). These inefficient patterns perpetuate stress responses and desensitise chemoreceptors, making breathing regulation more difficult (Boyadzhieva & Kayhan, 2021).

Neurocognitively, chronic stress reduces prefrontal activity weakening top-down regulation of limbic circuits such as the amygdala. This imbalance can increase reactivity, impair decision-making, and entrench hyperarousal (Ashhad et al., 2022). Inefficient breathing and dysregulated physiology thereby form a feedback loop with cognitive dysfunction sustaining the symptoms of PTSD (Boyadzhieva & Kayhan, 2021). In contrast, adaptive breathing patterns, typically slower rates of around 6–10 breaths per minute, promote CO_2 balance, vagal activation, and higher HRV. These changes support autonomic flexibility and smoother transitions between sympathetic and parasympathetic states (Fincham, Strauss, et al., 2023). Efficient regulation is reinforced by prefrontal modulation of

stress responses, fostering emotional resilience and sustained self-regulation (Boyadzhieva & Kayhan, 2021).

Evidence for breathing interventions

Breathing-based interventions have shown consistent benefits for regulating stress and autonomic function. Laborde et al. (2022), in a meta-analysis of 223 studies, reported that breathing techniques reliably increased parasympathetic activity, as reflected in increases of HRV, following both single and multi-session interventions. Similarly, Steffen et al. (2021) found that a 6-breaths-per-minute exercise outperformed compassion-focused therapy breathing, while Lin et al. (2022) showed that just four sessions of HRV biofeedback significantly enhanced HRV compared to controls. Collectively, these findings highlight the effectiveness of slow-paced breathing (<10 breaths/min) in improving stress regulation (Zaccaro et al., 2018).

Less attention has been given to high ventilation breathwork (HVB), techniques involving rapid or deep breathing such as holotropic breathwork, cyclic hyperventilation, or the Wim Hof method. Though historically rooted in practices such as yogic pranayama and Buddhist Tummo breathing (Brown & Gerbarg, 2012), HVB has more recently been explored in community and clinical contexts including prisons and psychiatric wards (Brewerton et al., 2012; Grof & Grof, 2023). A meta-analysis by Fincham, Katar, et al. (2023) suggested that HVB reduces stress, anxiety, and depression, though the evidence base remains limited and methodological detail is often sparse.

Whilst promising, breathing interventions such as HVB carry potential risks, including light-headedness, anxiety, and dissociative experiences, especially in vulnerable populations. Conditions such as hypertension, epilepsy, and panic disorder may contraindicate certain practices, and prolonged hyperventilation can induce altered states of

consciousness (Fincham, Katar, et al., 2023). These risks highlight the need for carefully structured protocols and clinical oversight when applying HVB techniques.

Training the autonomic nervous system

Voluntary breathwork can be understood as operant behaviour, where repeated engagement is reinforced by both physiological and psychological outcomes. Through consistent practice, individuals can shape autonomic regulation, reduce conditioned hyperarousal, and strengthen behavioural flexibility (Ley, 1999, 2001). Neuroimaging evidence supports this behavioural perspective. Voluntary breath control activates cortical and subcortical regions involved in sensorimotor integration, emotion regulation, and autonomic processing, including the hippocampus, amygdala, and prefrontal cortex (Ashhad et al., 2022; Herrero et al., 2018; McKay et al., 2003). Regular breathwork may therefore enhance prefrontal regulation over limbic and autonomic systems, promoting resilience to stress.

Breathwork may also offer an accessible pathway to autonomic training compared with physical exercise. Whereas exercise primarily conditions the autonomic nervous system through metabolic demand and cardiovascular adaptation (Belinger et al., 2016), breathwork directly modulates autonomic activity through controlled respiratory patterns, providing more immediate effects on HRV and emotional state (Balban et al., 2023; Zaccaro et al., 2018), making breathwork especially suitable for populations with physical limitations or avoidance of traditional treatment settings. Given the role of avoidance and autonomic dysregulation in PTSD, structured breathwork represents a plausible pathway for reducing conditioned hyperarousal, re-establishing tolerance to interoceptive arousal, and fostering psychological flexibility (Jerath et al., 2015).

Breathing techniques used in the current study

I examined a structured breathing intervention combining cyclic hyperventilation, extended breath-holds, and a Valsalva-type manoeuvre, practiced across two to five rounds, followed by a recovery phase. While the combined use of these techniques has received limited empirical investigation, each has independent evidence of physiological and psychological benefits. Cyclic hyperventilation and extended breath-holds are core elements of practices such as the Wim Hof Method and Tummo breathing, both of which have shown to improve stress regulation and autonomic functioning (Fincham, Katar, et al., 2023; Kox et al., 2014; Kozhevnikov et al., 2013).

Beyond the research setting, a three-phase protocol has been implemented in applied contexts. The Breath Connection (https://www.thebreathconnection.org/) has delivered over 22 courses through the Curtis Palmer Program (https://curtispalmerprogram.org/), reaching more than 500 UK veterans, police officers, and healthcare personnel, with growing adoption by charities, probation services, and NHS staff training initiatives. These reports suggest feasibility and high acceptability among operational personnel. Each component targets a distinct aspect of autonomic regulation. Cyclic hyperventilation transiently increases sympathetic activity, exposing individuals to interoceptive cues of arousal, supporting extinction learning (Kox et al., 2014; Rhinewine & Williams, 2007). Extended breath-holds activate baroreflex mechanisms and enhance acceptance of interoceptive stimuli (Bourdas et al., 2024). Valsalva-type manoeuvres provide a controlled cardiovascular challenge, increasing baroreflex sensitivity and HRV, thereby engaging adaptive stress-regulation processes (Jha et al., 2018; Saldaña García et al., 2020). When combined in a structured sequence, these techniques arrange conditions that may promote physiological regulation and decrease avoidance behaviours through interoceptive exposure-based learning.

Further detail on the physiological mechanisms and behavioural activation underpinning each technique is provided in Appendix A.

Rationale

Although breathing interventions have shown promise for improving HRV and reducing PTSD-related symptoms, most research has focused on civilian populations and relied heavily on self-report outcomes. Few studies have examined military veterans and police officers who face unique stressors such as combat exposure, reintegration difficulties, stigma around help-seeking, fears of career impact, and limited access to traditional services (Fincham, Strauss, et al., 2023). This limits the applicability of existing findings to operational personnel.

Emerging evidence indicates that breathing interventions can benefit operational personnel. Shuman et al. (2023) reported improvements in depression and PTSD intrusion symptoms following a three-session HRV biofeedback intervention for veterans. Seppälä et al. (2014) found significant reductions in symptoms of PTSD and anxiety after a breathing-based meditation program, while Colgan et al. (2015) showed that mindful breathing reduced PTSD and depressive symptoms of veterans. However, findings on resting HRV remain mixed: some studies reported no change after daily practice (Balban et al., 2023), or improvements limited to specific HRV indices such as SDNN (Shuman et al., 2023), while others found progressive HRV gains with longer protocols (Lin et al., 2022; Lehrer et al., 2003).

Research with police populations, though limited, also suggests potential benefits. Tiwari et al. (2020) found that tactical breathing improved performance during simulated critical incidents in police trainees, while ultra-short HRV and respiratory measures successfully predicted stress and workload in training settings. Together, these findings

highlight the promise of breathing-based interventions as non-pharmacological strategies for enhancing psychological resilience and autonomic regulation.

Nonetheless, key gaps remain. Most studies were short in duration, lacked structured delivery, or did not target the specific occupational context of veterans and police. Few investigated online, accessible interventions that may help reduce barriers such as stigma or avoidance of traditional care. Likewise, questions remain about whether breathing practices produce lasting autonomic adaptations beyond transient HRV changes, and how best to optimise adherence and feasibility for operational personnel. Addressing these gaps, I evaluated a 10-session, online, structured breathing intervention, incorporating cyclic hyperventilation, extended breath-holds, and a Valsalva-type manoeuvre, designed specifically for veterans and police officers.

The present study

I hypothesised that a 10-session, online, dynamic breathing intervention would (H1) increase HRV and reduce resting heart rate, and (H2) improve self-reported scores of depression, anxiety, negative affect (NA), positive affect (PA), mindful awareness, and psychological flexibility. Finally, I anticipated that (H3) the intervention would be rated as both feasible and acceptable for home-based use, providing a potential early intervention pathway for veterans and police officers who may be reluctant to engage with traditional trauma-focused treatments.

Method

Participants

Participants were recruited via UK-based charitable organisations that support current and former police and military personnel (Appendix B). Primarily the Curtis Palmer Program (https://curtispalmerprogram.org) and Rock 2 Recovery (https://www.rock2recovery.co.uk).

These organisations circulated an information sheet (Appendix C) via email to potential participants, who then expressed an interest by contacting me directly.

To be eligible, individuals had to be military veterans or serving/retired police officers aged 18 to 60, with access to a smartphone, internet, and email, and the ability to install an app and view online video content. Those currently undergoing psychological treatment, or who had known cardiovascular conditions, or were pregnant were excluded.

Seventeen individuals completed the consent and screening process which included the Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001; Appendix D). Inclusion required a PHQ-9 score of 5 or higher and a score below 3 on Item 9 (assessing suicidal ideation). Four were excluded due to subthreshold scores. Ten participants were initially enrolled, with priority given to those reporting greater symptom severity. Two participants (veterans) later withdrew resulting in a final sample of eight (mean age = 45.25, SD = 9.71; age range = 25–56).

The final study group included one veteran, two dual-service members (veterans now in police roles), four active police officers, and one retired officer currently in a healthcare role. Participants all identified as white British. The mean baseline PHQ-9 score was 10.50 (SD = 4.63), reflecting moderate depressive symptoms. Detailed participant characteristics are in Table 1.

Table 1

Participant Characteristics

Participant	Group	Age	Gender	Status	PHQ-9
P1	1	56	Male	Veteran	15
P2	1	56	Male	Veteran/Police	18
P3	1	47	Male	Police (Retired)	8
P4	2	25	Female	Police	14
P5	2	47	Male	Police	9
P6	2	44	Female	Veteran/Police	5
P7	2	42	Female	Police	9
P8	2	45	Female	Police	6

Design

A single-subject, multiple-baseline-across-participants design was used, arranged into two baseline groups with three in the first group, and five in the second. Although initially designed with three groups of three participants, the groupings were revised following the withdrawal of two participants.

Ethical Approval

Ethical approval was granted by the University of Waikato Human Research Ethics Committee (Approval number: 2025#17). The approval was amended to permit inclusion of participants with severe depression (PHQ-9 score ≥ 20) and to incorporate a social validity questionnaire. These changes enabled the evaluation of the intervention's impact on higher-risk participants and the collection of feedback on the acceptability of the practice.

Study registration

This study was pre-registered with the Open Science Framework (OSF; https://osf.io/). Registration can be found at https://osf.io/7mwfq/.

Materials

Participants received a 10-day video-based breathing intervention created by 'The Breath Connection UK' (https://www.thebreathconnection.org/), an organisation specialising in breathwork and wellness courses for veterans, emergency services personnel, and civilians. The intervention consisted of 10 separate video sessions, each lasting between 20 and 40 minutes. Each session included a structured warm-up, three rounds of dynamic breathwork (progressively increasing to five rounds in later sessions), and concluded with a guided recovery phase. Participants were initially provided an introductory video explaining the three core breathwork techniques featured in the programme to familiarise them with the practices before beginning the intervention.

Participants were issued a Polar® H10 Heart Rate Sensor (Appendix E), funded by the 'Royal Marines Charity' (https://rma-trmc.org/), for monitoring their HRV. Each participant was emailed detailed setup instructions (Appendix F) explaining how to download and install the Elite HRV smartphone application (version 5.5.8 #79; https://elitehrv.com/), pair the app with the Polar® H10 sensor, and a procedure of how to export their daily raw data. The setup guide also included a study protocol and timeline to assist participants in tracking their progress throughout the study (Appendix G).

Measures

The primary dependent variable was resting HRV, measured using RMSSD along with heart rate. Participants recorded resting HRV for a 60-second period, within 20 minutes of waking from a full night's sleep. Data were collected using the Polar® H10 Heart Rate Sensor paired with the Elite HRV app (version 5.5.8, build #79).

Patient Health Questionnaire-9 (PHQ-9)

The PHQ-9 (Appendix D) was used both as a screening instrument and as a pre- and post-intervention measure to assess changes in self-reported depressive symptoms. The PHQ-9 is a widely validated 9-item self-report scale designed to screen for major depressive disorder and evaluate symptom severity. Each item is rated on a 4-point Likert scale from 0 ("Not at all") to 3 ("Nearly every day"), yielding a total score between 0 and 27. Cut-off scores indicate symptom severity: 5–9 (mild), 10–14 (moderate), 15–19 (moderately severe), and 20–27 (severe). The PHQ-9 has demonstrated strong psychometric properties. Kroenke et al. (2001) reported high internal consistency (Cronbach's $\alpha = .89$). The PHQ-9 is also widely used to monitor symptom change in response to psychological and pharmacological interventions (Kroenke et al., 2001). The PHQ-9 has also been employed in studies evaluating HRV-based and breathing-focused interventions, supporting its relevance for the

current study (Economides et al., 2020). In my sample, internal consistency of the PHQ-9 pre-intervention was acceptable (Cronbach's α = .76).

During screening, participants were required to score ≥ 5 to allow for the detection of changes among those presenting with at least mild depressive symptoms. Whilst lower thresholds increase sensitivity, they may also yield more false positives; higher thresholds increase specificity but risk excluding participants who might still benefit. Participants who scored 3 on Item 9 (indicating suicidal ideation nearly every day) were excluded for safety reasons; those with higher total scores but lower suicidality were monitored. Table 2 lists the measures used in the study.

Table 2

Measures Used in the Study

Measure	What it measured	Frequency
DAS-A	Anxiety level in the last 24hrs	Daily
PHQ-9	Depression in the last 2 weeks	Screening, post, and follow-up
GAD-7	Anxiety level in the last week	Pre, post, and follow-up
PANAS	Positive and negative affect	Pre, post, and follow-up
MAAS	Mindfulness, attention and awareness	Pre, post, and follow-up
AAQ-II	Psychological flexibility	Pre, post, and follow-up
Social validity	Perceived acceptability of practice	Post

Daily Assessment of Symptoms –Anxiety (DAS-A)

The DAS-A (Appendix H) is an 8-item self-report instrument designed to monitor symptoms of anxiety, particularly amongst individuals diagnosed with Generalised Anxiety Disorder (GAD). Each item is rated on a Likert-type scale, is suitable for daily administration, and allows for the tracking of symptom change in response to interventions. The DAS-A has demonstrated high internal consistency, with Cronbach's alpha reported between 0.77 to 0.91 (Morlock et al., 2008). These values support its reliability in measuring anxiety symptoms, particularly within brief or time-limited treatments.

Although the DAS-A was initially administered three times during the intervention phase (totalling 24 administrations across eight participants), only six responses were received. Due to the low response rate and concerns about participant burden, the measure was withdrawn to reduce fatigue and support adherence to the study's core procedures.

Generalised Anxiety Disorder-7 (GAD-7)

The GAD-7 (Appendix I) was used as a pre- and post-intervention measure to assess changes in self-reported generalised anxiety symptoms. The GAD-7 is a 7-item self-report questionnaire designed to screen for probable cases of GAD and to evaluate symptom severity. Each item is rated on a 4-point Likert scale ranging from 0 ("Not at all") to 3 ("Nearly every day"), with a total score range of 0 to 21. Symptom severity cut-off scores classify anxiety as: 5–9 (mild), 10–14 (moderate), and 15–21 (severe anxiety). A validation study by Spitzer et al. (2006) found that the GAD-7 demonstrated high internal consistency (Cronbach's $\alpha = .92$) and strong test-retest reliability (intraclass correlation = .83). The GAD-7 criterion and construct validity have been confirmed through comparisons with structured clinical interviews and functional health outcomes, whilst its strong associations with functional impairment suggest its potential value for monitoring intervention effects over time (Spitzer et al., 2006). In my sample, internal consistency of the GAD-7, pre-intervention was $\alpha = .68$.

Positive and Negative Affect Schedule (PANAS)

The PANAS (Appendix J) was administered pre- and post-intervention to assess affective states. It has two 10-item subscales measuring Positive Affect (PA) and Negative Affect (NA), each rated on a 5-point Likert scale from 1 ("Very slightly or not at all") to 5 ("Extremely"). PA reflects high energy, enthusiasm, and engagement, whereas NA captures subjective distress and unpleasant emotional states.

The original PANAS validation by Watson et al. (1988) reported excellent internal consistency (α = .86–.90 for PA; α = .84–.87 for NA) and supported the scales' factorial, convergent, and discriminant validity. Retest reliability over an 8-week interval was also strong (*r* = .68 for PA; *r* = .71 for NA), supporting its utility in longitudinal designs. The PANAS can be adapted to assess either state or trait affect by modifying the instructional timeframe; I used it to evaluate trait-level changes over the course of the intervention. Reliability in military populations has also been demonstrated, with internal consistency values of α = .88 (PA) and α = .84 (NA) (Gomes & Teixeira, 2016). In my sample, internal consistency on the PANAS at pre-intervention was excellent (α = .92 for PA; α = .85 for NA).

Mindful Attention Awareness Scale (MAAS)

The MAAS (Appendix K) was used as a pre- and post-intervention measure to assess participants' self-reported dispositional mindfulness. The MAAS is a 15-item self-report scale that captures the frequency of open, receptive attention to, and awareness of present-moment experiences. Items were rated on a 6-point Likert scale ranging from 1 ("Almost always") to 6 ("Almost never"), with higher scores reflecting greater mindfulness. Internal consistency across samples has ranged from α = .80 to .87, and test-retest reliability over a 4-week period showed an intraclass correlation of .81, indicating excellent stability (Brown & Ryan, 2003). Confirmatory factor analysis supported a unidimensional structure across both college and general adult populations (Brown & Ryan, 2003). The MAAS has negatively correlated with scores of depression, anxiety, neuroticism, and self-consciousness, and positively with scores of self-esteem, positive affect, life satisfaction, vitality, autonomy, and competence (Brown & Ryan, 2003). In my sample, internal consistency of the MAAS at pre-intervention was α = .69.

Acceptance and Action Questionnaire–II (AAQ-II)

The AAQ-II (Appendix L) was included as a pre- and post-intervention measure of psychological flexibility, a core component of Acceptance and Commitment Therapy (ACT). The AAQ-II is a 7-item self-report measure designed to assess experiential avoidance and cognitive fusion, both of which reflect difficulties in accepting unwanted thoughts and feelings. Items are rated on a 7-point Likert scale ranging from 1 ("Never true") to 7 ("Always true"), with lower scores indicating greater psychological flexibility. Bond et al. (2011) found that the AAQ-II demonstrated strong psychometric properties, with internal consistency coefficients ranging from α = .78 to .88**,** and test–retest reliability of *r* = .81 over a 3-month period. The AAQ-II also showed robust convergent validity with measures of depression, anxiety, and quality of life, supporting its use in both clinical and non-clinical populations (Bond et al., 2011). In my study, internal consistency of the AAQ-II pre-intervention was excellent (α = .92).

Social validity questionnaire

I developed a brief 6-item Social Validity Questionnaire (Appendix M) to assess participants' perceptions of the acceptability, relevance, and feasibility of the breathwork intervention. The first five items were rated using a 5-point Likert scale (1 = "Not at all" to 5 = "Extremely") and explored perceived acceptability of the practice, confidence in following the technique correctly, recognising impacts of stress-related behaviours (e.g., sleep, alcohol use, disrupted routines), likelihood of continued use, and likelihood of recommending the practice to other veterans or police officers. The sixth item was open-ended and invited participants to share any difficulties experienced during the breathwork sessions or to provide general feedback.

I structured the social validity questionnaire in accordance with established social validity principles which emphasise three core components: relevance (the extent to which

the intervention addresses meaningful personal concerns), social significance (the importance of the intervention's goals in enhancing quality of life), and practicality (the feasibility and ease of use of the intervention in real-world settings) (Foster & Marsh, 1999).

Procedure

Respondents to the participant information sheet (Appendix C) were sent a link to the initial screening questionnaire (PHQ-9) and the consent form (Appendix N) via Qualtrics (www.qualtrics.com/au/). Ten eligible participants were then asked to provide basic demographic information (Table 1), and were mailed a Polar® H10 Heart Rate Sensor, along with a detailed setup sheet (Appendix F) to help them familiarise themselves with the monitor and the Elite HRV app. Contact information of supporting services was also included (Appendix O).

Once all participants had received their Polar® H10 Heart Rate Sensor, they were sent the remaining four pre-study questionnaires (Table 2), along with a start date to begin collecting baseline data. Participants emailed their raw data via the Elite HRV app daily during the baseline phase to help monitor the stability of the readings. A minimum of 5 days of baseline data was required. Participants remained in baseline until their data demonstrated signs of stability assessed using a median trend line to confirm that the data showed no consistent upward or downward trend. Once readings appeared stable, the intervention phase commenced. Start times for each participant were staggered with a minimum of 2 days between participants in accordance with What Works Clearinghouse (WWC) guidelines for multiple-baseline designs. This design element was implemented to meet WWC evidence standards without reservations (Kratochwill et al., 2010). Participants were initially allocated into three groups as their baseline readings became stable.

Once cleared to proceed to the intervention phase, participants were sent the first five breathwork sessions and invited to begin their breath-work practice, completing a maximum

of one session per day. They were encouraged to take rest days as needed within a self-paced 20-day intervention window. Upon completing their 10 breathwork sessions, participants were sent five post-study questionnaires followed by the social validity survey.

A follow-up was conducted approximately 6-weeks post intervention, where participants were invited to complete a further round of questionaries and provide 5 days of HRV data.

Participants were initially asked to complete the DAS-A every few days. However, due to a low early response rate, this measure was withdrawn to minimise participant fatigue.

Data analysis

I produced all figures, including behaviour-analytic graphs used to monitor HRV and heart rate, in Microsoft® Excel for Mac (Version 16.97.2).

Participants' daily 60-second HRV recordings were analysed using Kubios HRV Lite (version 4.1.2; https://www.kubios.com/). Raw R-R interval files were imported to extract RMSSD and heart rate. Beat correction was applied using the 'strong' threshold-based filter, selected for its ability to reduce artefactual noise in short-term recordings while preserving physiological signal integrity. Where corrected beats exceeded 5%, I re-evaluated with a less aggressive setting to avoid suppressing valid variability, consistent with recommendations by Alcántara et al. (2020).

I calculated effect sizes using the Nonoverlap of All Pairs (NAP) method (Parker & Vannest, 2009). NAP estimates the probability that a randomly selected intervention data point will exceed a baseline data point. NAP offers advantages over other nonoverlap indices by providing stronger discriminability, alignment with visual analysis, and ease of calculation. Interpretation guidelines suggest values of 0–.65 for a weak effect, .66–.92 for a medium effect, and .93–1.0 for a large effect (Parker & Vannest, 2009).

I used the Reliable Change Index (RCI) to calculate pre- and post-intervention psychological measures to determine whether observed changes exceeded what could be expected by chance or measurement error. Test–retest reliability coefficients and normative standard deviations from prior validation studies were used to calculate thresholds for each measure, with scores exceeding ±1.96 considered indicative of clinically significant change (Jacobson & Truax, 1991).

Psychological assessment scores met assumptions of normality and were analysed using paired-samples *t* tests in IBM SPSS Statistics (Version 30.0.0.0 [172]).

Results

Individual results

P1

RMSSD was initially stable during baseline, with a slight upward trend observed across the extended 6-day phase (slope = 1.13; Figure 2). During the intervention, RMSSD initially increased following the first two breathwork sessions before declining across the remainder of the first week. From Session 6 onward, values stabilised near baseline and then rose during Sessions 9–10, peaking at 16.79. A slight increase in RMSSD was observed across phases (Baseline *Mdn* = 10.82; Intervention *Mdn* = 10.97). Heart rate showed a similar inverse pattern (Baseline *Mdn* = 74.59; Intervention *Mdn* = 73.93; Appendix P).

Analysis using NAP indicated that the 10-day intervention had a weak effect on RMSSD compared with baseline (NAP = 0.54). Similarly, a weak effect was observed for heart rate (NAP = 0.54), reflecting minimal non-overlap between phases.

At screening, P1 scored 15 on the PHQ-9, indicating moderately severe self-reported depressive symptoms. Following the intervention, improvements were observed in self-reported depression (PHQ-9), mindful awareness (MAAS), and psychological flexibility

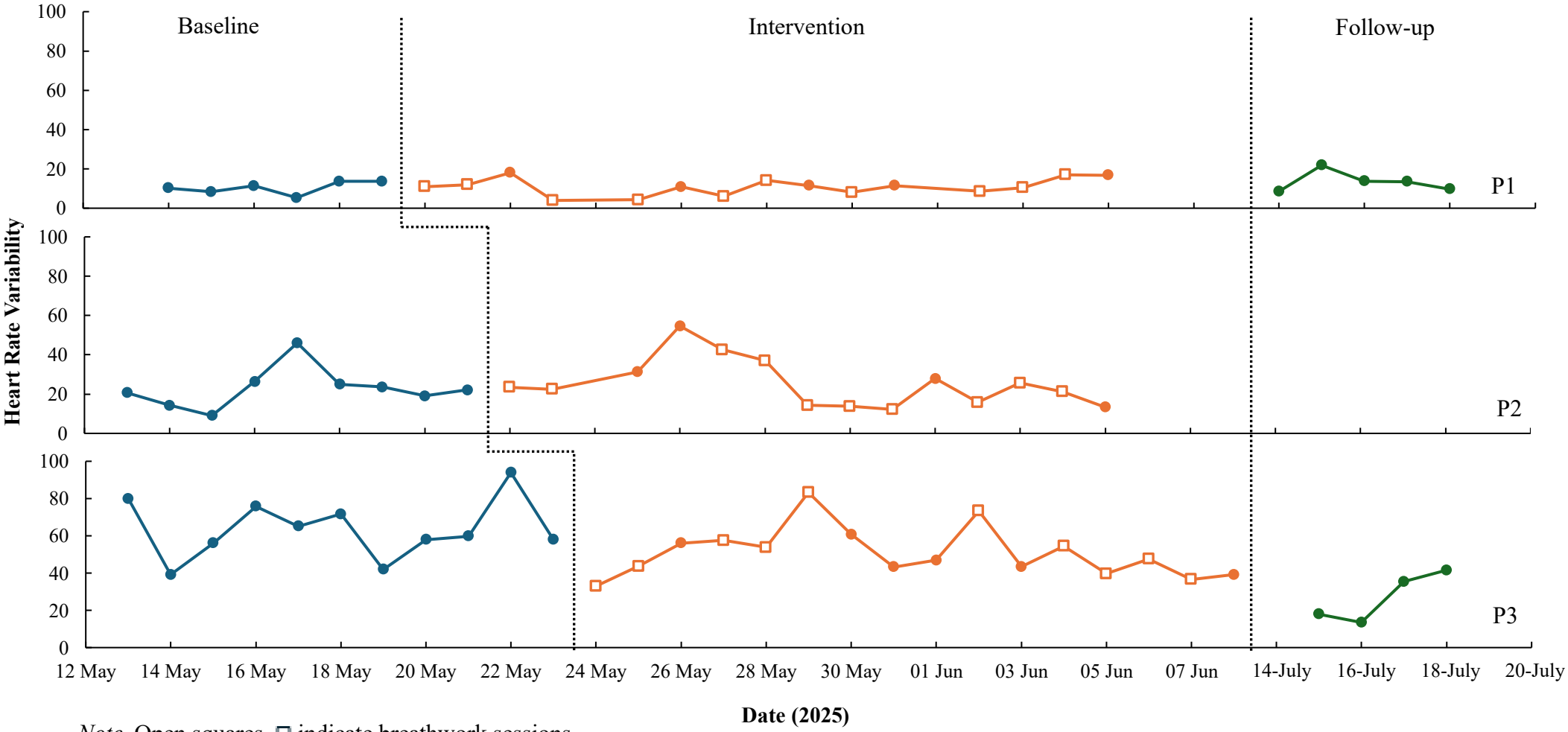
(AAQ-II) scores. Clinically significant reductions were also noted in self-reported anxiety (GAD-7) and NA scores. PA scores decreased (Table 3).

At follow-up, RMSSD increased relative to baseline (*Mdn* = 13.56) alongside a reduction in resting heart rate (*Mdn* = 70.38). A NAP analysis indicated that the follow-up phase had a medium effect on RMSSD compared with baseline (NAP = 0.67) and a weak effect compared with the intervention phase (NAP = 0.61; Figure 2).

For psychological measures at follow-up, improvements in self-reported depression, anxiety, mindful awareness, and psychological flexibility scores were maintained compared with pre-intervention scores. Self-reported NA scores returned to baseline levels, whereas self-reported PA scores continued to decline (Table 4).

Figure 2

Daily Resting HRV Measured in RMSSD of Group 1



Note. Open squares ☐ indicate breathwork sessions.

Table 3

Reliable Change Index (RCI) Scores Across Psychological Measures Pre- and Post-Intervention

	PHQ-9			GAD-7			PA			NA			MAAS			AAQ-II		
Participant	Pre	Post	RCI	Pre	Post	RCI	Pre	Post	RCI	Pre	Post	RCI	Pre	Post	RCI	Pre	Post	RCI
P1	15	11	-1.70	9	3	**-3.19***	46	36	**-2.86***	25	15	**-2.86***	2.73	3.33	1.73	25	18	-1.58
P2	18	7	**-4.66***	16	3	**-6.91***	20	29	**2.57***	39	26	**-3.71***	2.87	3.47	1.73	39	32	-1.58
P3	8	7	-0.42	11	3	**-4.26***	21	30	**2.57***	27	18	**-2.57***	2.73	3.8	**3.09***	30	30	0.00
P4	14	4	**-4.24***	12	2	**-5.32***	25	23	-0.57	35	21	**-4.00***	2.47	3.4	**2.68***	34	25	**-2.03***
P5	9	5	-1.70	6	2	**-2.13***	34	19	**-4.29***	16	15	-0.29	3.47	3.73	0.75	14	12	-0.45
P6	5	3	-0.85	11	2	**-4.79***	21	26	1.43	17	20	0.86	2.13	2.87	**2.13***	32	27	-1.13
P7	9	5	-1.70	6	1	**-2.66***	22	27	1.43	19	16	-0.86	3.53	3.93	1.15	24	17	-1.58
P8	9	6	-1.27	6	4	-1.06	21	20	-0.29	16	16	0.00	3.4	4.53	**3.26***	26	26	0.00

Note. Positive RCI values indicate improvement for PA and MAAS. For all other measures, improvement is reflected by negative RCI values.
*Indicates clinically significant change at the ≥ 1.96 threshold.

Table 4

Reliable Change Index (RCI) Scores Pre-Intervention and at Follow-Up

	PHQ-9			GAD-7			PA			NA			MAAS			AAQ-II		
Participant	Pre	Post	RCI	Pre	Post	RCI	Pre	Post	RCI	Pre	Post	RCI	Pre	Post	RCI	Pre	Post	RCI
P1	15	8	**-2.97***	9	6	-1.60	46	35	**-3.14***	25	25	0.00	2.73	3.20	1.36	25	17	-1.81
P3	8	5	-1.27	11	0	**-5.85***	21	39	**5.14***	27	14	**-3.71***	2.73	3.33	1.73	30	19	**-2.48***
P4	14	5	**-3.81***	12	3	**-4.79***	25	30	1.43	35	20	**-4.29***	2.47	3.67	**3.46***	34	29	-1.13
P6	5	5	0.00	11	2	**-4.79***	21	31	**2.86***	17	18	0.29	2.13	2.87	2.13*	32	21	**-2.48**
P7	9	8	-0.42	6	4	-1.08	22	23	0.29	19	20	0.29	3.53	3.73	0.58	24	22	-0.45
P8	9	5	-1.70	6	3	-1.60	21	24	0.86	16	15	-0.29	3.4	4.00	1.73	26	20	-1.35

Note. Positive RCI values indicate improvement for PA and MAAS. For all other measures, improvement is reflected by negative RCI values.
*Indicates clinically significant change at the ≥ 1.96 threshold.

P2

P2 spent 9 days in the baseline phase, during which RMSSD was relatively stable with a slight upward trend (slope = 1.35; Figure 2). During the intervention phase, RMSSD increased sharply, peaking at 54.66 before returning to baseline levels after 9 days. RMSSD then remained stable for the remainder of the 15 days it took for P2 to complete the 10-day breathwork intervention. A slight increase in RMSSD was observed from baseline to intervention (Baseline *Mdn* = 22.05; Intervention *Mdn* = 22.96). Heart rate followed a similar inverse pattern (Baseline *Mdn* = 68.74; Intervention *Mdn* = 67.21; Appendix P).

A NAP analysis indicated that the 10-day breathwork intervention had a weak effect on both RMSSD (NAP = 0.55) and heart rate (NAP = 0.36), suggesting minimal non-overlap between phases.

For pre-intervention self-report measures, P2 scored 18 on the PHQ-9 (moderately severe depression) and 16 on the GAD-7 (severe anxiety). Following the 10-day breathwork intervention, P2 reported improvements across all outcomes, including clinically significant symptom reduction in self-reported depression (PHQ-9), anxiety (GAD-7), and NA scores, as well as a clinically significant increase in their self-reported PA score (Table 4).

P2 was unable to participate in the follow-up.

P3

P3 spent 11 days in the baseline phase, during which RMSSD showed high variability and an overall slight decline (slope = –1.14; Figure 2). Data remained variable during the intervention phase, with an initial change from 33.99 to a peak of 83.26 after four sessions, before declining steadily across the remainder of the 16-day period that P3 took to complete the 10 breathwork sessions. A decrease in RMSSD was observed from baseline to intervention (Baseline *Mdn* = 59.85; Intervention *Mdn* = 47.16). Heart rate remained

relatively stable across phases, with a slight increase from baseline to intervention (Baseline *Mdn* = 50.83; Intervention *Mdn* = 52.95; Appendix P).

The intervention had a weak effect on RMSSD (NAP = 0.26) and a medium effect on heart rate (NAP = 0.75).

For pre-intervention self-report measures, P3 scored 8 on the PHQ-9 and 11 on the GAD-7, indicating mild depression and moderate anxiety. Following the intervention, P3 scores improved across all measures except psychological flexibility (AAQ-II) that saw no change. Clinically significant improvements were observed in self-reported anxiety (GAD-7), PA, NA, and mindful awareness scores (MAAS) (Table 3).

At the follow-up, P3 reported maintaining a daily breathwork practice whilst also managing some external stressors. RMSSD decreased relative to baseline and intervention (*Mdn* = 26.71), while resting heart rate increased (*Mdn* = 64.30). A NAP analysis indicated weak effects of the follow-up compared with baseline (NAP = 0.02) and compared with intervention (NAP = 0.08; Figure 2).

For psychological outcomes at follow-up, P3's scores improved across all self-reported measures compared with pre-intervention, including a clinically significant increase in their self-reported psychological flexibility score (AAQ-II) (Table 4).

P4

P4 spent 6 days in the baseline phase, during which RMSSD was initially stable, an upward shift was observed after an outlier, as indicated by a split-middle trend analysis (slope = 7.44; Figure 3). During the intervention, RMSSD stayed near baseline for 5 days, dipped after the second breathwork session on Day 6, then gradually increased before declining again toward the end of the 20-day period, resulting in an overall increase from baseline to intervention (Baseline *Mdn* = 35.39; Intervention *Mdn* = 42.11). Heart rate followed an inverse pattern (Baseline *Mdn* = 59.74; Intervention *Mdn* = 57.76; Appendix P).

A NAP analysis indicated a medium effect of the intervention on RMSSD (NAP = 0.75) and a weak effect on heart rate (NAP = 0.40).

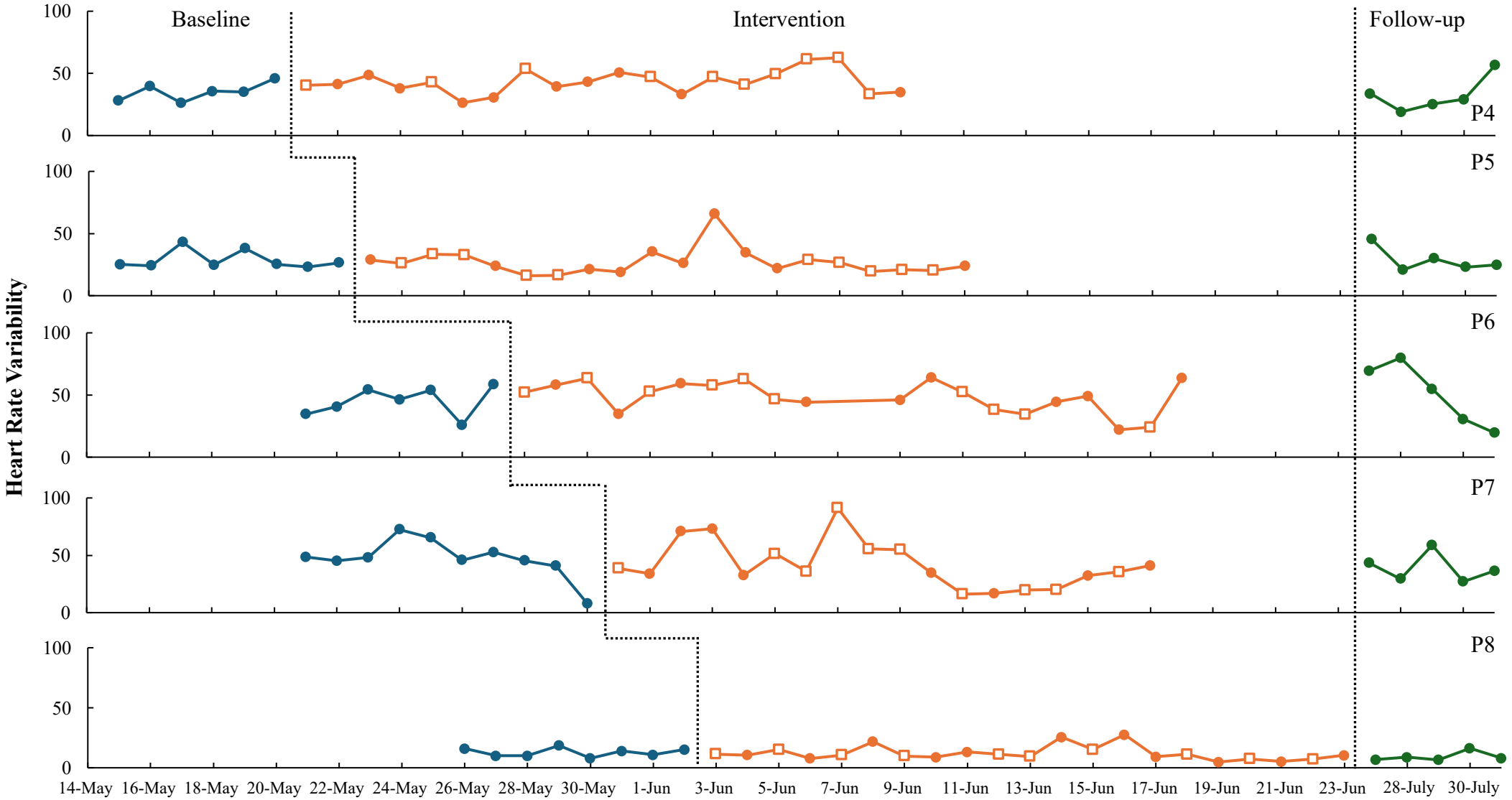
For the pre-intervention screening, P4 scored 14 on the PHQ-9 and 11 on the GAD-7, indicating symptoms at the upper end of moderate severity for both depression and anxiety. Following the 10-day breathwork practice, P4's scores showed clinically significant improvements in all self-report measures except PA scores which had decreased slightly (Table 3).

At follow-up (49 days post-intervention), RMSSD was lower than both baseline and intervention levels (*Mdn* = 29.16), while resting heart rate was slightly higher than during baseline and intervention (*Mdn* = 61.02). A NAP analysis indicated weak effects of the follow-up on RMSSD compared with both baseline (NAP = 0.33) and intervention (NAP = 0.23; Figure 3).

For the psychological measures, improvements across all self-reported outcomes were maintained at follow-up relative to pre-intervention (Table 4).

Figure 3

Daily Resting HRV Measured in RMSSD of Group 2



Note. Open squares ☐ indicate breathwork sessions.

P5

P5's baseline RMSSD was generally stable across the 8-day phase as confirmed by split-middle trend analysis (slope = 0.27; Figure 3). During the intervention, RMSSD initially remained within baseline levels, declined after the third breathwork session on Day 4, then returned to baseline levels following the fifth session. This pattern, aside from one outlier, continued throughout the 20-day intervention period, with values showing little overall change from baseline to intervention (Baseline *Mdn* = 25.18; Intervention *Mdn* = 24.89). Heart rate remained stable across phases (Baseline *Mdn* = 61.14; Intervention *Mdn* = 60.86; Appendix P).

A NAP analysis indicated a weak effect of the intervention on RMSSD (NAP = 0.39) and heart rate (NAP = 0.51).

P5 scored nine on the PHQ-9 pre-intervention reflecting mild depressive symptoms. Following the intervention, scores improved across all self-reported psychological measures except PA which showed a clinically significant decline. Notably, self-reported scores of anxiety symptoms (GAD-7) improved from moderate severity to mild (see Table 3).

At the follow-up, RMSSD remained similar to both baseline and intervention levels (*Mdn* = 24.60), whilst heart rate was slightly higher (*Mdn* = 60.62). A NAP analysis indicated weak follow-up effects on RMSSD compared with baseline (NAP = 0.40) and intervention (NAP = 0.57; Figure 3).

P5 did not complete the psychological measures at follow-up.

P6

P6 spent 7 days in baseline phase, during which RMSSD appeared stable, though trend analysis indicated a gradual upward slope (slope = 3.32; Figure 3). Across the 22-day intervention, RMSSD increased initially before a sharp decline, coinciding with a self-reported episode of alcohol use. RMSSD then stabilised near baseline, with further reductions

later in the phase following additional reports of alcohol use and disrupted sleep. A slight increase in RMSSD was observed from baseline to intervention (Baseline *Mdn* = 46.26; Intervention *Mdn* = 48.17). Heart rate remained stable across phases (Baseline *Mdn* = 55.09; Intervention *Mdn* = 56.36; Appendix P).

A weak effect of the intervention on both RMSSD (NAP = 0.58) and heart rate (NAP = 0.59) reflected minimal non-overlap between phases.

For pre-intervention measures, P6 scored eight on the PHQ-9 (mild depression), seven on the GAD-7 (moderate anxiety), and reported low mindful awareness scores (MAAS = 2.13). Post-intervention scores indicated improvement across all domains, including clinically significant improvements in both self-reported anxiety and mindful awareness scores (Table 3).

At follow-up, P6 reported that they engaged in breathwork for the first 2 weeks before pausing due to personal and occupational demands. RMSSD continued to increase (*Mdn* = 54.79), while heart rate also showed a slight increase (*Mdn* = 57.11). A NAP analysis indicated weak follow-up effects on RMSSD compared with both baseline (NAP = 0.60) and intervention (NAP = 0.55; see Figure 3).

Improvements in self-reported anxiety, PA, mindful awareness, and psychological flexibility scores were maintained. Self-reported depression scores returned to baseline levels, while NA remained slightly elevated from pre-intervention (see Table 4).

P7

P7 spent 9 days in baseline. Excluding an outlier on Day 9, split-middle trend analysis indicated that the baseline was stable (slope = –0.56; see Figure 3). During the 18-day intervention, RMSSD was highly variable but largely remained within baseline range. Breathwork adherence was limited during the first week with a single session completed. After five consecutive sessions, RMSSD fell below baseline before gradually increasing

toward the end of the intervention. A decrease in RMSSD was observed from baseline to intervention (Baseline *Mdn* = 48.07; Intervention *Mdn* = 35.68). Heart rate followed an inverse pattern (Baseline *Mdn* = 65.79; Intervention *Mdn* = 75.52; Appendix P).

A NAP analysis indicated a weak effect of the intervention on RMSSD (NAP = 0.36) and a medium effect on heart rate (NAP = 0.74).

For pre-intervention measures, P7 reported mild symptoms of depression (PHQ-9 = 5) and anxiety (GAD-7 = 6), alongside the highest mindful awareness score of all participants (MAAS = 3.53). Post-intervention scores reflected improvements across all measures, including a clinically significant reduction in self-reported anxiety scores (Table 3).

At follow-up, P7 reported some initial breathwork engagement. RMSSD slightly increased from intervention levels (*Mdn* = 36.34), whilst heart rate decreased (*Mdn* = 74.12). A NAP analysis indicated weak follow-up effects on RMSSD compared with both baseline (NAP = 0.26) and intervention (NAP = 0.50; Figure 3).

Psychological improvements across all measures were maintained at follow-up, except for NA which had regressed to slightly above baseline scores (Table 4).

P8

P8 spent 8 days in the baseline phase, during which RMSSD remained stable, as confirmed by split-middle trend analysis (slope = –0.14; Figure 3). Across the 21-day intervention phase, RMSSD remained near baseline levels. A moderate increase was observed after Session 6, followed by a brief dip and a gradual rise over the final sessions. A slight decrease in RMSSD was observed from baseline to intervention (Baseline *Mdn* = 12.41; Intervention *Mdn* = 11.79). Heart rate followed an inverse pattern with a slight increase (Baseline *Mdn* = 85.95; Intervention *Mdn* = 86.58; Appendix P).

The NAP analysis indicated weak intervention effects for both RMSSD (NAP = 0.38) and heart rate (NAP = 0.51).

For pre-intervention measures, P8's psychological assessment scores indicated mild symptoms of depression and anxiety. Post-intervention scores showed improvements in P8's self-reported symptoms of depression and anxiety, with clinically significant improvements in their mindful awareness scores (MAAS). No change was reported in P8's scores of psychological flexibility (AAQ-II) or NA, while P8's self-reported PA scores declined slightly (Table 3).

At follow-up, P8 reported completing breathwork approximately once every 6–10 days. RMSSD continued to decrease compared with baseline and intervention (*Mdn* = 7.91). Resting heart rate showed a slight reduction (*Mdn* = 83.17). A NAP analysis indicated weak follow-up effects on RMSSD relative to baseline (NAP = 0.20) and intervention (NAP = 0.30; Figure 3).

Psychological outcome scores at follow-up showed improvements across all measures compared to pre-intervention, including a slight improvement in their self-reported PA score (Table 4).

Summary of results

Across participants, NAP analyses indicated that the 10-session breathwork intervention had a weak effect on resting RMSSD and heart rate, with a similar effect at follow-up. A medium effect was observed in one case (P4).

Based on individual RCI results, all participants demonstrated improvement in their self-reported anxiety, depression, and mindful awareness scores, while six of the eight participants also improved in their self-reported NA and psychological flexibility scores. Self-reported PA scores were less consistent across the sample, with four participants reporting a decline (Table 3). At the follow-up, improvements in self-reported anxiety, depression, mindful awareness, and psychological flexibility scores were largely maintained, alongside a rebound in PA scores (Table 4).

A paired-samples *t* test comparing pre- and post-intervention psychological scores showed statistically significant improvements across outcomes, with large effect sizes as indicated by Cohen's *d* (Table 5). A second *t* test comparing pre-intervention scores to the follow-up scores again found large effect sizes for self-reported depression, anxiety, mindful awareness, and psychological flexibility scores. Medium effect sizes were observed for both self-reported negative and PA scores (Table 6).

Table 5

Effects of a 10-Session Breathwork Intervention on Psychological Measures

Measure	Pre-test *M* (SD)	Post-test *M* (SD)	Mean Diff.	95% CI	*t*	Sig (2-tailed)	Cohen's *d*
PHQ-9	10.50 (4.63)	6.38 (2.67)	4.13	[0.30, 7.95]	2.55	.038*	0.90
GAD-7	9.63 (3.58)	2.50 (0.93)	7.13	[4.15, 10.10]	5.66	<.001**	2.00
MAAS	2.92 (0.51)	3.63 (0.49)	-0.72	[-0.98, -0.46]	-6.51	<.001**	-2.30
NA	24.25 (8.92)	18.38 (3.82)	5.88	[0.50, 11.25]	2.59	.036*	0.92
PA	26.25 (9.19)	26.25 (5.60)	0.00	[-7.36, 7.36]	0.00	1.000	0.00
AAQ-II	27.75 (8.12)	23.63 (6.52)	4.13	[0.65, 7.60]	2.81	.026*	0.99

Note. *$p < .05$ ** $p < .001$; $df = 7$.

Table 6

Effects of a 10-Session Breathwork Intervention on Psychological Measure at Follow-Up

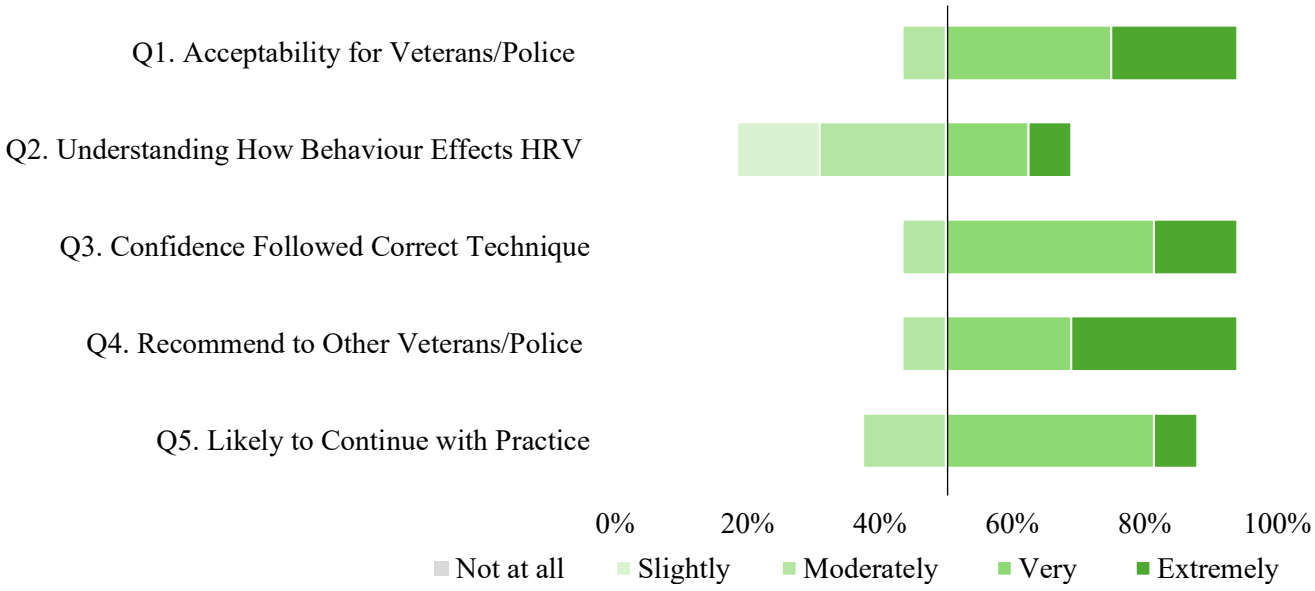
Measure	Pre-test *M* (SD)	Follow-up *M* (SD)	Mean Diff.	95% CI	*t*	Sig (2-tailed)	Cohen's *d*
PHQ-9	9.50 (4.14)	6.00 (1.55)	3.50	[-0.36, 7.36]	2.33	.067	0.95
GAD-7	9.17 (2.63)	3.00 (2.00)	6.17	[2.05, 10.28]	3.85	.012*	1.58
MAAS	2.83 (0.54)	3.47 (0.41)	- 0.64	[0.14, -2.87]	-4.69	.005**	-1.92
NA	23.17 (7.28)	18.67 (3.98)	4.50	[-3.29, 12.29]	1.48	.198	0.60
PA	26.00 (9.92)	30.33 (6.19)	-4.33	[-14.48, 5.81]	-1.10	.322	-0.45
AAQ-II	28.50 (4.09)	21.33 (4.13)	7.17	[3.44, 10.89]	4.95	.004**	2.02

Note. *$p < .05$ ** $p < .001$; $df = 5$.

All participants rated the intervention at least moderately acceptable for use with veterans and police officers who may be reluctant to engage in traditional mental health services, with 88% rating it as either "very" or "extremely" acceptable ($M = 4.25$). Eighty eight percent of participants reported that they were 'extremely' confident that they followed the correct technique as outlined in the breathwork videos. In terms of future use, all participants indicated they were at least "moderately" likely to continue the breathwork practice independently, with 76% reporting "very" or "extremely" likely ($M = 3.88$; Figure 4).

Figure 4

Social Validity Measures



Discussion

I evaluated a 10-session, self-administered online breathwork intervention targeting PTSD-related physiological and psychological symptoms of veterans and police officers. I hypothesised that 10 days of dynamic breathwork practice would increase resting HRV (RMSSD) and reduce resting heart rate. Although four of eight participants showed

improvements in RMSSD, no meaningful effect on physiological measures was found. However, in line with the secondary hypothesis, participants reported significant psychological improvements in scores of depression, anxiety, NA, mindful awareness, and psychological flexibility. PA scores remained largely unchanged. All participants reported high levels of engagement, adherence, and acceptability, indicating the intervention's feasibility and relevance for this population.

Psychological findings

If the structured breathwork technique used in this study engaged interoceptive exposure, autonomic modulation, and operant reinforcement of self-regulation, then improvements in psychological outcomes would be expected. All eight participants reported reductions in depression, anxiety, NA, and increases in mindful awareness and psychological flexibility, supported by large pre-post effect sizes (Tables 3 and 4). These results echo those of prior breath-based interventions reporting strong psychological effects, even after brief protocols (Balban et al., 2023; Seppälä et al., 2014; Shuman et al., 2023).

In contrast, self-reported PA showed no meaningful group-level change with four participants (P1, P4, P5, P8) reporting declines. This may reflect individual differences in response and variability introduced by the online, self-paced format. The within-subject design highlighted these differences: while some participant scores improved, others did not, with the paired-samples *t* test indicating no overall significant effect. Despite no overall gain in self-reported PA, all participants showed meaningful change across all other psychological metrics (see Table 3). These divergent patterns may suggest distinct underlying mechanisms. For example, reductions in self-reported anxiety may reflect fear extinction and threat attenuation, whereas PA is theorised to be more closely tied to processes that broaden cognitive resources (Fredrickson, 2004). From a behavioural perspective, reductions in distress and increases in PA reflect different processes. These can be understood through the

lens of RFT, where PA may enhance psychological flexibility by supporting more adaptive relational responding, allowing previously aversive stimuli to acquire new and less threatening meanings via transformation of stimulus functions (Dymond & Roche, 2009). Dynamic breathwork may also act primarily on fear-based systems rather than those generating positive emotion. This would be consistent with Hoffman et al.'s (2022) findings that PTSD treatments reduced self-reported NA without equivalent gains in self-reported PA (see also Van Cappellen et al., 2018).

Psychological flexibility scores (AAQ-II) showed the least improvement of all outcomes apart from self-reported PA. Only P4 met the threshold for clinically significant change, while P3 and P8 showed no change (see Table 3). This limited change may reflect the AAQ-II's focus on trait-level experiential avoidance, which is often less responsive to brief interventions (Akbari et al., 2022; Wolgast, 2014). Although dynamic breathwork implicitly targets avoidance by requiring sustained contact with uncomfortable interoceptive stimuli, it omits core ACT components such as values clarification or cognitive defusion (Hayes et al., 1996).

The intervention's structure involving repeated cycles of arousal and recovery mirrors interoceptive exposure practices known to reduce conditioned aversive responding to internal stimuli (Craske et al., 1997; 2008). From a behavioural perspective, targeting response classes rather than discrete trauma cues offers the potential for broader generalisation, reducing avoidance across contexts. This carries important ethical and practical advantages for veterans and police, for whom direct confrontation with traumatic stimuli may be unsafe or unfeasible; as evidenced by high dropout rates and reports of re-traumatisation in trauma-focused treatments (Edwards-Stewart et al., 2021; Haagen et al., 2015). These findings are also consistent with the behavioural mechanisms outlined in Figure 1, where interoceptive arousal ordinarily functions as a CMO-R that increases avoidance. Within the structured

context of dynamic breathwork, repeated exposure can transform these cues into MOs that establish opportunities for extinction and inhibitory learning, leading to a reduction in avoidant behaviours. When paired with values-based goals, such practices may generate augmentals, further supporting adaptive engagement (Craske et al., 1997; Craske et al., 2008). The dynamic breathwork pattern used in the present study offered a means of arranging controlled contact with aversive interoceptive stimuli. My findings indicate that this specific breathwork practice has potential clinical utility.

Social validity

Consistent with my third hypothesis, participants perceived the current intervention as highly acceptable. This finding is important given the persistent barriers operational personnel face when accessing conventional mental health care. Stigma, concerns over confidentiality, career impact, and limited access frequently deter veterans and police from seeking support (Clary et al., 2023). Many also view evidence-based treatments such as trauma-focused CBT, EMDR, or pharmacotherapy as emotionally taxing or potentially re-traumatising, contributing to high dropout rates (Edwards-Stewart et al., 2021; Haagen et al., 2015). In contrast, the current practice was online, self-paced, and likely reduced these obstacles by offering private, flexible engagement. This aligns with recent frameworks promoting accessible interventions that minimise stigma and logistical burden (Mobbs & Bonanno, 2018; Schuman et al., 2022).

High participant engagement may also reflect the intervention's behavioural and physiological focus. Breathwork bypasses trauma narration and cognitive processing, instead using embodied strategies that produce rapid, perceptible shifts in arousal. This aligns with evidence from Edwards-Stewart et al. (2021), who found that disclosure-free protocols improved engagement among avoidance-prone populations, suggesting that adherence may be enhanced through predictable formats that reduce ambiguity. In my study, the progression

from hyperventilation to recovery may have increased perceived control by systematically exposing participants to intense interoceptive cues, followed by predictable regulation, a pattern theorised to reduce conditioned hyperarousal and build distress tolerance (Craske et al., 1997; Fincham, Katar, et al., 2023; Kox et al., 2014).

Challenge-based formats may further enhance engagement among operational personnel. Military and law enforcement populations often prefer demanding, mastery-oriented experiences over passive relaxation, aligning with occupational values of resilience and toughness (Adler et al., 2015; Andersen et al., 2015). This may explain the high acceptability of dynamic breathwork, which combined structured delivery with significant physiological intensity. However, the ~40-minute session length may limit sustainability. Prior studies have identified session duration as a key variable in breathwork feasibility (Fincham, Katar, et al., 2023; Lin et al., 2023). The moderate likelihood of continued use by participants (M = 3.88) may reflect this barrier.

Lastly, the two participants with the lowest baseline RMSSD (P1 and P8) also reported the lowest social validity scores, suggesting a possible link between autonomic inflexibility and lower perceived acceptability. This aligns with models linking reduced vagal tone to diminished regulatory capacity, which may make physiologically intense practices more challenging for some individuals without initial support (Shaffer & Ginsberg, 2017).

Physiological findings

If dynamic breathwork modulates autonomic function, then improvements in physiological markers would be expected. However, I found no significant changes in resting HRV as measured by RMSSD, or heart rate, following the 10-session protocol used in this study (Figures 2 and 3). This is notable given that RMSSD is a well-established index of vagal tone and autonomic flexibility, both of which are often diminished in trauma-exposed populations (Shaffer & Ginsberg, 2017). The absence of change in RMSSD contrasts with

prior evidence suggesting that structured breathing can enhance parasympathetic function via baroreflex engagement (Balzarotti et al., 2017; Lehrer & Gevirtz, 2014; Shuman et al., 2023). However, physiological outcomes in breathwork studies remain inconsistent and appear to vary with intervention type, metric selection, number of sessions, and individual differences such as baseline health and lifestyle (Lehrer et al., 2003; Lin et al., 2023).

State versus Trait Changes in HRV

As discussed in the introduction, breathwork has been found to reliably induce acute (state) increases in HRV driven by baroreflex engagement and vagal activation at resonance frequencies (Balzarotti et al., 2017; Boyadzhieva & Kayhan, 2021). Meta-analyses confirm these transient gains with slow-paced breathing (Zaccaro et al., 2018). However, translating these effects into lasting (trait-level) improvements in resting HRV appears more difficult. Sustained change may require longer, intensive protocols with biofeedback under controlled conditions (Lehrer et al., 2003; Lin et al., 2023). Even then, findings remain mixed. Some studies report modest or metric-specific gains (see Shuman et al., 2023), while others observe no meaningful physiological change even after 4 weeks of daily practice (Balban et al., 2023; Ketelhut et al., 2023). These inconsistencies suggest that short-term, self-administered interventions, particularly those without real-time feedback, may not be sufficient to alter autonomic flexibility, despite psychological benefits (Koch et al., 2019; Shaffer & Ginsberg, 2017).

Choice of HRV Metrics

Another possible explanation for the null finding is the HRV metric selected. I focused on RMSSD, a time-domain index considered a robust marker of resting parasympathetic tone (Shaffer & Ginsberg, 2017). However, RMSSD may not reflect other forms of autonomic adaptation such as the oscillatory variability captured by frequency-domain measures like LF power or broader indices like SDNN. For example, Lehrer et al.

(2003) found increases in LF power following 10 sessions of HRV biofeedback, and Shuman et al. (2023) observed gains in SDNN, but not RMSSD. Similarly, Zaccaro et al. (2018) concluded that slow breathing reliably elevates LF power during practice, while evidence for lasting RMSSD change was again limited. These findings suggest that RMSSD may underestimate physiological effects that emerge through frequency-based mechanisms.

Technique variation

Differences in the type of breathing technique may also explain the mixed HRV outcomes across studies. Trait-level improvements are most consistently linked to slow breathing at or near resonance frequency (~0.1 Hz), often paired with biofeedback to reinforce cardiorespiratory coupling (Lehrer et al., 2003; Lin et al., 2023; Zaccaro et al., 2018). In contrast, the current protocol used dynamic cycles of hyperventilation, breath retention, and Valsalva-like manoeuvres designed to induce intermittent physiological stress rather than stable oscillations. Whilst such patterns can produce acute shifts in respiratory alkalosis, intermittent hypoxia, and sympathetic arousal (Kox et al., 2014), their capacity to promote baroreflex conditioning remains unclear. Evidence from other non-resonance techniques supports this variability: daily cyclic sighing produced no sustained HRV gains (Balban et al., 2023), while alternate nostril and high-frequency yoga breathing have produced negligible or paradoxical effects (Telles et al., 2011). Similarly, Ketelhut et al. (2023) found that the Wim Hof Method elicited strong physiological responses during practice but produced no meaningful change in resting HRV.

Measurement considerations

The absence of HRV changes may also reflect data quality limitations. Ultra-short recordings like the 1-minute RMSSD measures used in this study are highly sensitive to artifacts and transient fluctuations (Bellinger et al., 2023). Even with beat correction thresholds (≤5%), residual noise and interpolation can distort RR variability, particularly in

short windows where each correction has greater proportional impact. As Alcántara et al. (2020) noted, minor artifacts can shift HRV values by up to 50%, which may explain the irregular spikes seen for P5 and P7 (Figure 3). While RMSSD is generally robust in short durations, its reliability diminishes when respiratory rate, movement, or signal stability are uncontrolled (Bellinger et al., 2023).

High variability in data

The high variability in RMSSD may strongly reflect participants' individual lifestyle factors and situational stress during the study. Participants P1, P3, P4, and P6 reported fluctuations in sleep, alcohol intake, and exposure to acute stressors such as high-intensity exercise (Balzarotti et al., 2017; Shaffer & Ginsberg, 2017; Tan et al., 2011). As a marker of vagal tone, RMSSD is sensitive to behavioural and physiological states, often decreasing after sympathetic arousal or inflammation (Shaffer & Ginsberg, 2017). These contextual factors may have masked any autonomic benefits from a brief protocol. Similar findings in HRV biofeedback trials show that adherence alone does not predict HRV gains without stable daily routines and reduced external stressors. This may suggest that dynamic breathwork, while effective psychologically, may be insufficient on its own to shift resting HRV (Fincham, Katar, et al., 2023; Shuman et al., 2023; Zaccaro et al., 2018).

Lag in autonomic change

As in the study by Balban et al. (2023), my findings could suggest that psychological benefits of breathwork may emerge sooner than measurable autonomic changes, pointing to a possible temporal lag in physiological adaptation. Balban et al. (2023) observed improved mood and reduced stress following structured breathing, yet physiological markers showed minimal or inconsistent change. This dissociation could suggest that affective gains may be mediated more by attentional and emotional regulation mechanisms than by immediate vagal remodelling. Similar trends appear in studies using high-ventilation protocols, which elicit

strong psychological responses without sustained HRV improvements (see Kox et al., 2014). Meta-analyses reinforce that lasting autonomic benefits may require extended or biofeedback-supported resonance protocols (Lehrer et al., 2003; Zaccaro et al., 2018). Taken together, these findings perhaps highlight a need to distinguish between short-term psychological shifts and long-term physiological adaptation when evaluating intervention efficacy.

Strengths

A key strength of this study was its small-*N*, multiple-baseline design, which staggered intervention onset across participants to enhance internal validity and allow replication of effects (Butler et al., 2011; Kratochwill et al., 2010). The methodological quality was appraised against the SCED Scale (Tate et al., 2008) and What Works Clearinghouse (WWC) standards for single-case design. Target outcomes were operationally defined and repeatedly measured with each phase containing at least five data points with more than six phases in total, meeting WWC standards for evidence without reservations. Raw data were reported graphically and supplemented by effect size and NAP indices, allowing both visual and statistical evaluation of change.

A second strength was the focus on operational personnel; a group largely absent from breathwork research. Most studies target general or student samples (e.g., Balban et al., 2023), with limited work involving veterans (Seppälä et al., 2014; Shuman et al., 2023), and almost none with police officers. By including both, this study tested feasibility and acceptability in populations that face barriers to traditional care, extending breathwork research into applied clinical contexts.

A third strength was the intervention's ecological validity. Participants engaged independently, without intensive researcher input mirroring real-world application. Adherence was high, with all participants completing the required sessions. By assessing

both physiological and psychological outcomes, the study captured changes across multiple levels of functioning offering a broader perspective than studies focused solely on HRV metrics (e.g., Kox et al., 2014; Lehrer et al., 2003; Lin et al., 2023; Zaccaro et al., 2018), or psychological outcomes alone (e.g., Seppälä et al., 2014).

A fourth strength was the inclusion of a follow-up. By repeating both physiological and psychological measures, I was able to evaluate the durability of the intervention effects. Use of the RCI further strengthened analysis by identifying meaningful individual-level improvements beyond measurement error (Jacobson & Truax, 1991).

Lastly, a final strength of this study was the focus on resting HRV. By using repeated, standardised RMSSD recordings, I was able to test whether autonomic gains extended beyond practice. Although no significant changes were observed, this trait-level approach provided a stringent, ecologically relevant test of breathwork's potential to influence baseline vagal tone from a 10-session protocol (Shaffer & Ginsberg, 2017).

Limitations

Physiological outcomes showed no significant change. This may reflect the short duration of the intervention or the use of ultra-short HRV recordings, which are more prone to artefacts and less sensitive to small shifts in vagal tone. While 60-second samples are commonly used in applied settings, longer recordings may offer greater reliability in future research.

The protocol was brief and self-directed, with no real-time feedback or coaching. While this improves scalability, it may limit the intensity or consistency needed to produce lasting physiological change. The dynamic nature of the breathwork may also differ in effect from slower, resonance-based protocols more commonly linked to HRV gains (Lehrer et al., 2003; Lin et al., 2023; Zaccaro et al., 2018).

All psychological outcomes were assessed via self-report measures. While assessment tools are widely used and appropriate for evaluating change in applied settings, self-report data may have been influenced by participant expectations or interpretation of items.

Lastly, except for the PANAS, normative values were based on civilian populations, which may limit their applicability to operational personnel with distinct psychological and physiological profiles.

Future directions

Several future directions emerge from my findings. First, systematic replication using similar single-subject designs across diverse operational cohorts would strengthen the evidence base and clarify the consistency of psychological effects. Extending the protocol duration may allow for greater physiological adaptation, as trait-level changes in HRV may require longer or more frequent exposure than a 10-session format. The inclusion of alternative HRV metrics such as LF power or SDNN, could provide a more comprehensive index of autonomic change, particularly given the dynamic nature of this type of breathwork. In addition, further exploration of individual response patterns, including dose–response relationships and baseline predictors of change, may help identify which participants are most likely to benefit from breathwork interventions.

As illustrated in Figure 1, the intervention arranged controlled contact with interoceptive stimuli that ordinarily function as a CMO-R for avoidance, creating opportunities for extinction and inhibitory learning that support adaptive behavioural repertoires. A recent scoping review concluded that interoceptive exposure is a safe and promising transdiagnostic strategy with no serious adverse events reported across studies (Farris et al., 2025). Evidence supports the use of interoceptive exposure in conditions such as panic disorder, PTSD, health anxiety, IBS, and in pharmacological contexts (e.g., the discontinuation of benzodiazepines), with the strongest outcomes observed when embedded

in multicomponent behavioural interventions (Craske et al., 2008; Farris et al., 2025). These findings highlight interoceptive exposure's adaptability, and the potential of dynamic breathwork as an innovative pathway for trauma-focused care. My suggestion for future work would be to directly test whether dynamic breathwork facilitates extinction processes by examining whether repeated exposure to interoceptive arousal reduces conditioned responding to trauma cues (uncoupling the CR from the CS).

Conclusion

In this study, I aimed to bridge the gap between physiological regulation and behavioural outcomes by evaluating the impact of a 10-session, self-administered dynamic breathwork protocol on both physiological and psychological outcomes for veterans and police officers. Although resting HRV and HR did not show statistically significant change, participants reported meaningful improvements with large effect sizes across multiple psychological domains including anxiety, depression, mindfulness, NA, and psychological flexibility. Notably, these effects occurred within a brief, low-cost, online format and without external facilitation. High engagement and acceptability ratings demonstrated that dynamic breathwork is both feasible and well-received among operational personnel, a population that often encounters barriers to traditional support.

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Appendix A

Mechanics of Breathwork Used in This Study

Cyclic hyperventilation

Cyclic hyperventilation involves rapid, deep breathing cycles that can significantly reduce arterial carbon dioxide (CO_2) levels, leading to hypocapnia (low CO_2) and a temporary increase in blood pH (respiratory alkalosis) (Fincham, Katar, et al., 2023). Since CO_2 is the primary driver of respiratory urge, its depletion reduces chemoreceptor sensitivity in the medulla oblongata, momentarily suppressing the reflexive need to breathe (McKay et al., 2003). This process alters autonomic function by promoting cerebral and peripheral vasoconstriction, shifting blood flow dynamics, and inducing a transient sympathetic response. As a result, individuals may experience symptoms such as dizziness, headaches, tingling sensations (paraesthesia), muscle cramps, and light-headedness due to reduced cerebral blood flow and altered oxygen delivery. This acute autonomic stress activation results in increased heart rate, reduced vagal tone, and increased circulating catecholamines (epinephrine and norepinephrine), further stimulating arousal, alertness, and stress adaptation (Kox et al., 2014).

Hyperventilation-induced hypocapnia enhances neural excitability, potentially contributing to increased alertness and sensory sensitivity. It also activates the sympathetic nervous system, resulting in elevated epinephrine release, reinforcing physiological arousal. However, with prolonged hyperventilation, excessive CO_2 depletion may impair cerebral oxygen delivery due to vasoconstriction, leading to cognitive disorganisation, attentional deficits, or difficulty concentrating (Kox et al., 2014; Sparing et al., 2007).

From a behavioural perspective, Ley (2001) explored how breathwork practices that alter respiratory patterns, such as cyclic hyperventilation, can be conceptualised through both respondent and operant conditioning. Physiological arousal states including increased heart

rate, dizziness, and breathlessness may become interoceptive conditioned stimuli for individuals with PTSD and anxiety-related disorders due to their somatic association with trauma-related distress. This conceptualisation aligns with the findings of Tan et al. (2013), who described how persistent autonomic dysregulation underpins PTSD's hyperarousal features. Over time, the avoidance of these internal sensations can be negatively reinforced as temporary relief from discomfort perpetuates conditioned responses and maintains hyperarousal patterns.

To counteract the cycle of conditioned hyperarousal and avoidance behaviours, Craske et al. (1997, 2008) demonstrated that systematic exposure to interoceptive stimuli such as breathlessness, dizziness, and racing heart, can effectively weaken the learned association between internal arousal and perceived danger, promoting extinction and inhibitory learning over time. Additionally, Ley (1999) and Laborde et al. (2022) highlighted how engagement in breath control strategies can enhance self-regulation and distress tolerance over time, illustrating the role of operant reinforcement in breathwork practices.

During cyclic hyperventilation, the resulting reduction in arterial CO_2 blunts baroreceptor sensitivity, disrupting vagal modulation of the heart. This shift contributes to a temporary increase in heart rate and a reduction in HRV as sympathetic nervous system activity becomes dominant. However, the oscillatory nature of breath cycles continues to produce rhythmic heart rate fluctuations, suggesting that HRV may be modulated rather than entirely suppressed even under sympathetic dominance. While this process may induce short-term autonomic instability, repeated exposure appears to foster greater autonomic flexibility, enhancing the capacity to regulate stress responses across varying physiological states (Balzarotti et al., 2017; Fincham, Kartar, et al., 2023; Laborde et al., 2022).

Beyond behavioural and autonomic effects, cyclic hyperventilation also influences systemic metabolism. Laffey and Kavanagh (2002) demonstrated that reduced CO_2 levels

shift the oxygen-haemoglobin dissociation curve via the Bohr effect, temporarily impairing oxygen delivery. This physiological shift may underpin the transient states of heightened arousal, energy, and mental focus observed in high-performance and altered-state breathwork (Fincham, Katar, et al., 2023). Kozhevnikov et al. (2013) further showed that Tummo breathing, a structured form of cyclic hyperventilation, increased core body temperature and supported cognitive performance. Fincham, Katar, et al. (2023) also suggested that high ventilation breathwork may recalibrate autonomic function to improve resilience towards physiological stress. Supporting this, Kox et al. (2014) demonstrated that cyclic hyperventilation within the Wim Hof Method, enhanced autonomic adaptation and moderated inflammatory responses. Additionally, Miller and Nielsen (2015) found that holotropic breathwork, which involved prolonged cyclic hyperventilation, led to positive changes in temperament, reductions in aggressive behaviour, and increased self-awareness, supporting its role in psychological resilience and character development. Taken together, these findings suggest that cyclic hyperventilation may hold preventative and integrative value across physiological and psychological domains.

Cyclic hyperventilation may also induce beneficial physiological adaptations and psychological effects. Upon cessation, CO_2 levels gradually normalise, triggering a parasympathetic rebound that supports autonomic recalibration and restores vagal modulation (Shaffer & Ginsberg, 2017; Tan et al., 2013). Over time, repeated exposure to these physiological fluctuations may enhance autonomic flexibility, disrupt maladaptive avoidance patterns, and increase tolerance to internal arousal cues. These characteristics position cyclic hyperventilation specifically as a promising interoceptive exposure technique for addressing dysregulation in individuals with symptoms associated with PTSD (Balban et al., 2023; Fincham, Katar, et al., 2023). However, individuals with pre-existing cardiovascular or

neurological conditions may experience heightened stress responses and therefore careful implementation is recommended (Fincham, Katar et al., 2023).

Cyclic hyperventilation summary

In summary, cyclic hyperventilation reduces CO_2 levels which diminishes chemoreceptor sensitivity and suppresses the urge to breathe. Respiratory alkalosis raises blood pH, leading to cerebral and peripheral vasoconstriction. These changes activate the sympathetic nervous system, increases heart rate, decreases HRV, and elevates catecholamine levels. Individuals may experience dizziness, paraesthesia, muscle cramps, and shifts in cognitive function. In individuals with PTSD or anxiety, this sympathetic arousal can reinforce stress responses and promote avoidance behaviours. However, despite sympathetic dominance, breath cycles maintain rhythmic HRV patterns. Additionally, hypocapnia influences oxygen delivery and may impact physical and cognitive performance. Breathwork practices such as Tummo breathing and the Wim Hof Method use cyclic hyperventilation to improve endurance, stress resilience, and metabolic efficiency.

Extended breath-holds

In contrast to cyclic hyperventilation, extended breath-holds introduce a distinct physiological stimulus by increasing exposure to rising CO_2 levels and the associated sensations such as air hunger and chest tightness. Rather than avoiding these sensations, individuals engage with them in a deliberate and structured way. This may support greater interoceptive awareness and improve tolerance for discomfort, particularly in those for whom these sensations have become conditioned aversive stimuli. Within this context, breath-holds may act as a form of graded exposure helping to reduce defensive responding, enhance parasympathetic flexibility, and promote more adaptive engagement with interoceptive stimuli (Fincham, Katar, et al., 2023; Ley, 1999, 2001). Empirical evidence supports these mechanisms. Kox et al. (2014) showed that a structured breathing intervention involving

breath retention after cycles of hyperventilation significantly elevated epinephrine levels and suppressed pro-inflammatory cytokine production. These results highlight the potential of controlled breathing sequences that include breath-hold phases to enhance physiological resilience and regulation of stress responsivity through autonomic and immune modulation. Over time, the ability to remain composed during episodes of breathlessness has been associated with improved vagal tone and emotion regulation (Balzarotti et al., 2017; Shaffer & Ginsberg, 2017). Likewise, as Ley (2001) noted, engagement in breath control may be operantly reinforced through its calming effects, supporting self-regulation of autonomic arousal.

The extended breath-hold technique in my study involved a full exhalation to residual volume followed by a retention phase. As lung volume decreases, intra-pulmonary pressure shifts dynamically, while intrathoracic pressure remains slightly negative due to the elastic recoil of the lungs and chest wall. This temporary reduction in intrathoracic pressure diminishes venous return to the heart, prompting short-term changes in cardiac output and arterial blood pressure. These shifts activate baroreceptors in the aortic arch and carotid sinus, initiating an autonomic reflex that helps maintain circulation homeostasis (Bourdas et al., 2022). During the breath-hold, rising CO_2 levels activate brainstem chemoreceptors, further adjusting autonomic tone and driving homeostatic responses. These changes also lead to a temporary drop in blood pH (respiratory acidosis) due to carbonic acid accumulation (Kusumaningtyas & Handari, 2024). Together with increased baroreflex sensitivity, respiratory acidosis facilitates vagal modulation, supporting parasympathetic recovery and contributes to a gradual slowing of heart rate (Bourdas et al., 2022).

Marabotti et al. (2013) found that maximal breath-holding preserved cardiac output and stroke volume despite reduced ejection fraction, suggesting that compensatory cardiac adjustments support circulatory stability during apnea. These findings highlight the capacity

of breath-hold techniques to reinforce cardiovascular resilience through sustained autonomic balance. In contrast, cyclic hyperventilation initially activates the sympathetic nervous system; however, when followed by structured breath-holding, it can recalibrate autonomic activity and promote physiological adaptability (Kox et al., 2014; Fincham, Strauss, et al., 2023).

With repeated practice, controlled breath-holds support vagal capacity, promoting autonomic balance, and may increase resilience to elevated CO_2 levels (Immanuela et al., 2023). These adaptations foster resilience to internal stressors and contribute to autonomic balance, even in the context of stress-related dysregulation (Kox et al., 2014). These benefits suggest that breath-hold training not only supports cardiovascular and autonomic stability but may also serve as a gateway to broader emotional self-regulation practices grounded in interoceptive awareness. Bourdas et al. (2022) went further by examining the role of breath-holding in elite freediving contexts, demonstrating its efficacy in promoting physiological adaptation to extreme internal stress. Their findings suggested that repeated, controlled exposure to breath-holds enhanced tolerance to physiological arousal, a mechanism increasingly applied in both military training and athletic recovery programmes.

While breath-holding offers physiological and psychological benefits, it must be practiced with caution due to potential risks. Fincham, Katar, et al. (2023) emphasised that because breath-holding induces controlled hypoxia, it should be conducted in structured settings to help avoid adverse effects such as dizziness or loss of consciousness.

Extended breath-hold summary

In summary, extended breath-holds lead to a gradual rise in CO_2 levels which intensifies vagal tone and elicits a series of autonomic adjustments. The accumulation of CO_2 lowers blood pH, inducing respiratory acidosis that stimulates brainstem chemoreceptors and initiates compensatory autonomic responses. These include enhanced baroreflex activation,

which stabilises blood pressure and reinforces parasympathetic dominance. As a result, heart rate initially decreases sharply due to strong vagal activation and then exhibits oscillatory patterns as sympathetic activity re-emerges. HRV tends to increase steadily, peaking mid-breath-hold before gradually declining. With repeated practice, individuals appear to develop greater resilience to elevated CO_2 levels alongside improved vagal modulation and enhanced autonomic flexibility. These physiological changes not only contribute to circulatory homeostasis and stress adaptation but also support the use of breath-hold techniques as structured interoceptive exposure methods.

Valsalva-type manoeuvre

The Valsalva-type manoeuvre used in my study involved forceful exhalation against a closed airway, temporarily increasing intrathoracic pressure and modulating autonomic activity. Brody et al. (1999) demonstrated that this technique evoked physiological responses resembling natural stress reactions. Consequently, it provides a controlled and repeatable method for autonomic training and assessment. Saldaña García et al. (2020) suggested that repeated exposure to the manoeuvre may enhance baroreflex sensitivity and blood pressure regulation, supporting its application in behavioural interventions targeting autonomic regulation.

Jha et al. (2018) demonstrated that the Valsalva manoeuvre elicited a dynamic autonomic response, beginning with sympathetic nervous system activation followed by baroreflex-mediated parasympathetic rebound. This sequence regulates heart rate through a well-documented four-phase hemodynamic cycle. Phase 1 (Onset of strain) involves forceful exhalation against a closed airway, increasing intrathoracic pressure and briefly elevating arterial blood pressure due to compression of thoracic vessels. In some individuals, this rapid pressure shift may elicit sensations of cranial pressure, or headache-like symptoms. Phase 2 (Sustained strain) is characterised by reduced venous return, leading to a drop in cardiac

output and arterial pressure. As circulation diminishes, individuals may experience light-headedness or visual dimming due to decreased cerebral perfusion. In response, the sympathetic nervous system activates increasing heart rate to compensate for reduced blood flow. Phase 3 (Release) begins with the sudden release of strain, resulting in an abrupt restoration of venous return and a transient drop in blood pressure. This rapid shift may induce dizziness or instability, particularly in those with orthostatic intolerance. Phase 4 (Recovery) is marked by a parasympathetic rebound, during which the baroreflex restores vagal tone and stabilises cardiovascular function. In some cases, this rebound may produce brief bradycardia or vagally mediated faintness. This sequence of autonomic adjustments highlights the Valsalva manoeuvre's utility in cardiovascular regulation and its potential as a training method for autonomic adaptation (Jha et al., 2018; Kim et al., 2019).

The Valsalva manoeuvre elicits a distinct autonomic shift, characterised by sympathetic activation during the strain phase and a parasympathetic rebound upon release (Jha et al., 2018). This biphasic response reflects autonomic reflex function and offers insight into how respiratory patterns modulate autonomic tone. Saldaña García et al. (2020) reported that while sympathetic activation during strain temporarily reduces HRV, the subsequent exhalation phase facilitates a parasympathetic response, restoring vagal tone. Since HRV indexes the body's ability to shift between autonomic states, structured exposure to Valsalva-type breathing patterns may improve autonomic responsiveness and support adaptive stress regulation (Ashhad et al., 2022).

In addition to its role in autonomic regulation, the Valsalva manoeuvre has been associated with baroreflex sensitivity (BRS) and emotional modulation. Di Credico et al. (2022) identified BRS derived from the Valsalva manoeuvre as a physiological marker that may buffer anxiety responses, particularly in individuals with high anxiety sensitivity. They demonstrated that higher BRS was associated with lower state anxiety during CO_2-induced

stress, suggesting that BRS may serve as a protective mechanism against hypercapnic reactivity. While the authors stop short of positioning the Valsalva manoeuvre itself as a treatment for anxiety symptoms, their findings highlight the link between autonomic function and emotional resilience. This supports the emerging view that enhancing baroreflex function through interventions such as controlled breathing, could represent a viable pathway for reducing vulnerability to stress and improving emotional regulation.

Despite its autonomic and cardiovascular benefits, the Valsalva manoeuvre must be applied with caution, particularly in individuals with hypertension, cardiovascular disease, or autonomic dysfunction, due to its potential to cause transient blood pressure fluctuations. Saldaña García et al. (2020) noted that the manoeuvre may provoke adverse responses including severe hypertension, arrhythmias, syncope, or, in rare cases, cerebrovascular complications, particularly in high-risk populations. Similarly, Jozwiak et al. (2024) described how abrupt hemodynamic changes induced by the manoeuvre may destabilise individuals with pre-existing cardiovascular conditions.

Valsalva manoeuvre summary

The Valsalva manoeuvre elicits a characteristic four-phase autonomic response. In Phase 1, the initiation of strain increases intrathoracic pressure, reducing venous return and activating baroreceptors. During Phase 2, continued strain leads to decreased cardiac output and a compensatory increase in sympathetic nervous system activity, resulting in elevated heart rate and a transient drop in blood pressure. Phase 3, marked by the release of strain, causes a brief drop-in heart rate and a temporary normalisation of blood pressure. In Phase 4, the recovery phase, baroreflex engagement restores vagal tone, leading to an increase in HRV and the reestablishment of autonomic stability. Heart rate follows a patterned sequence; an initial drop, a spike during SNS compensation, a brief decline post-release, and then oscillations reflecting baroreflex regulation. HRV briefly decreases upon pressure release but

gradually recovers during the parasympathetic rebound. Repeated practice of the manoeuvre appears to enhance autonomic flexibility and baroreflex sensitivity.

Recovery phase

Resonance breathing involves slow-paced diaphragmatic breathing at an individual's optimal frequency, typically between 4.5 and 6.5 breaths per minute, and concludes the breathwork practice. According to Lehrer et al. (2000, 2020), breathing at this personal resonance frequency produces the largest amplitude of heart rate. At this rate, the baroreflex and respiratory sinus arrhythmia align, generating a state of maximal oscillatory efficiency in the cardiovascular system. By promoting parasympathetic dominance, enhancing baroreflex sensitivity, and contributing to autonomic stability, this physiological synchrony may position resonance breathing as a potentially effective recovery intervention following recurrent episodes of cyclic hyperventilation, breath-holds, or Valsalva-like manoeuvres.

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Appendix B

Initial email

Subject: Request for Support – Veteran Mental Health Research

Morning {Redacted],

I hope you don't mind me reaching out. [Redacted] suggested you would be a great person to contact. I also want to take a moment to express my appreciation for the support that the RMA provided, which enabled me to attend the SRS reunion in 2023.

By way of introduction, I left the Royal Marines as an ML1 in 2008 before relocating to New Zealand. Like many others, I faced my own challenges post-service, however I received some invaluable support that helped me navigate through those times, and for that I remain incredibly grateful. Over the past six years, I have dedicated myself to supporting veterans. I am now in a position to contribute further through research into interventions for veteran mental health as part of my Master's thesis in Psychology at the University of Waikato, New Zealand.

About the Research
My study investigates the effectiveness of cyclic breathing techniques as a behavioural intervention for reducing stress and anxiety, including PTSD-related symptoms, amongst veterans. Participants will complete a 10-day guided breathing intervention from home, providing an accessible approach for those who may face barriers to traditional mental health services.

I have partnered with [Redacted] from The Breath Connection (Website link), who will provide the breathing protocols, while I will assess the impact using physiological measures (HRV, mean HR) and self-reported psychological measures. The goal is to evaluate whether cyclic breathwork is a scalable, cost-effective intervention for veterans' well-being.

Request for Support
I'm reaching out to ask whether the RMA would be willing to support this research in any of the following ways:

1. Participant Recruitment

Helping to identify and connect with 10 veterans (Royal Marines or others) experiencing mild to moderately severe symptoms of stress, anxiety, or depression (no formal diagnosis required).

2. Equipment Support

Assisting in securing 10 x Polar H10 heart rate monitors for participants (Amazon link) (approx. £799 for 10 units before potential discounts). The intention is to gift these devices to participants upon study completing to support their continued well-being.

Study Timeline

- Recruitment: April - May 2025
- Intervention: June - July 2025 (approximately 6 weeks total)
- Publication of results: Early 2026.

Next steps
I would love the opportunity to discuss this further and explore how we might collaborate. Please let me know if you'd be open to a chat at your convenience.

Thanks again for your time and consideration, I truly appreciate any support you can provide.

Kind regards,

Ben Pointer
Master of Applied Psychology Researcher
University of Waikato, New Zealand

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Appendix C

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Participants Information Sheet

The impact of a 10-session online breathing intervention on heart rate variability, mean heart rate, and anxiety in veterans: A multiple-baseline study.

The Project

This study aims to evaluate the effectiveness of cyclic breathing techniques in reducing stress and anxiety, including PTSD-related symptoms, in military veterans. Participants will complete a 10-day guided breathing intervention from home while tracking heart rate variability (HRV), mean heart rate (HR), and psychological measures. This research seeks to assess whether cyclic breathwork is an accessible, non-pharmacological intervention for supporting autonomic regulation and behavioural adaptation to stress in veterans.

Your Role

If you agree to participate, your involvement will include:

1. Baseline Measures (up to 7 days)
    - Recording HRV and HR every morning (~2 minutes) upon waking.
    - Completing one set of online psychological questionnaires (10–15 mins).
2. Breathing Intervention (10 sessions to be completed within 20 days)
    - Participating in daily guided breathwork sessions (~20 minutes/day) provided via an online video.
    - Continuing morning HRV & HR tracking (~2 minutes each morning upon waking).
    - Completing a short (8-item) questionnaire daily (~2 minutes).
3. Follow-Up Assessments
    - Completing final self-report questionnaires at:
        - Immediately after the intervention.
        - 6 weeks post-intervention.

Eligibility?

Inclusion Criteria:

- If you are a military veteran aged 18–60.
- You experience mild to moderately severe symptoms of stress, anxiety, or depression (*no formal diagnosis required*).
- Are willing to engage in a self-paced 10-day breathing practice from home to be completed within 14 days (~20 minutes per day).
- Own a smartphone or tablet with internet access.

Exclusion Criteria:

- If you are currently experiencing severe mental health distress requiring urgent clinical intervention.
- If you have a medical condition that may increase the risk of adverse symptoms, including:
    - Severe cardiovascular conditions
    - Epilepsy
    - Unmanaged hypertension
    - Severe panic disorders
    - Pregnancy

Risks?

- Breathing exercises are generally safe, some people experience temporary dizziness, tingling, or mild headaches.
- If you feel unwell, you can pause the session or stop altogether.
- If any distress occurs, you will be provided with support resources and can withdraw at any time.

Privacy

- Your privacy is our priority.
- You will be assigned a unique ID.
- Your name or personal details will not appear in any publications.
- All data will be securely stored with any personal details stored separately.
- You have a right to withdraw at any time.

Next Steps

1. If you are interested, speak to your case manager who will provide an overview of the study or email Ben direct (email link) or personal email: p.staff1976@gmail.com
2. If you provide verbal consent via email, you will receive:
    - A formal consent form
    - A Screening Questionnaire to confirm eligibility
3. If eligible, you will be provided further details and the materials for the study.

Ben Pointer RM, Master of Applied Psychology Researcher
School of Psychology, University of Waikato, New Zealand: (+64) 021 177 2387:
bp90@students.waikato.ac.nz

Supervisor: Dr. Rebecca Sargisson
Head of School of Psychology, University of Waikato: (+64) 022 070 2447:
Rebecca.sargisson@waikato.ac.nz

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Appendix D

Personal Details and
Screening Form PHQ-9
(via Qualtrics: https://www.qualtrics.com/)

Name	ID: (Provided by researcher)	Gender
Email	Age	Operational Service Yes/No

Over the last 2 weeks, how often have you been bothered by any of the following problems?
(Use "✓" to indicate your answer)

	Not at all	**Several days**	**More than half the days**	**Nearly every day**
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself or that you are a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed? Or the opposite, being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3

FOR OFFICE CODING + _____ + _____ + _____ = Total Score: _____

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Appendix E

Materials

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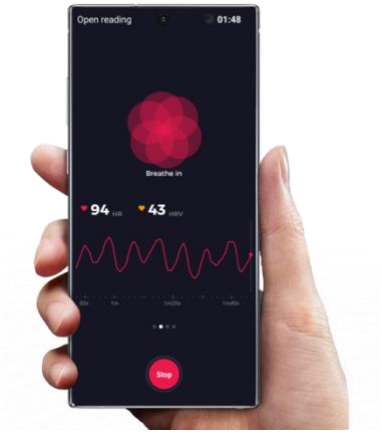
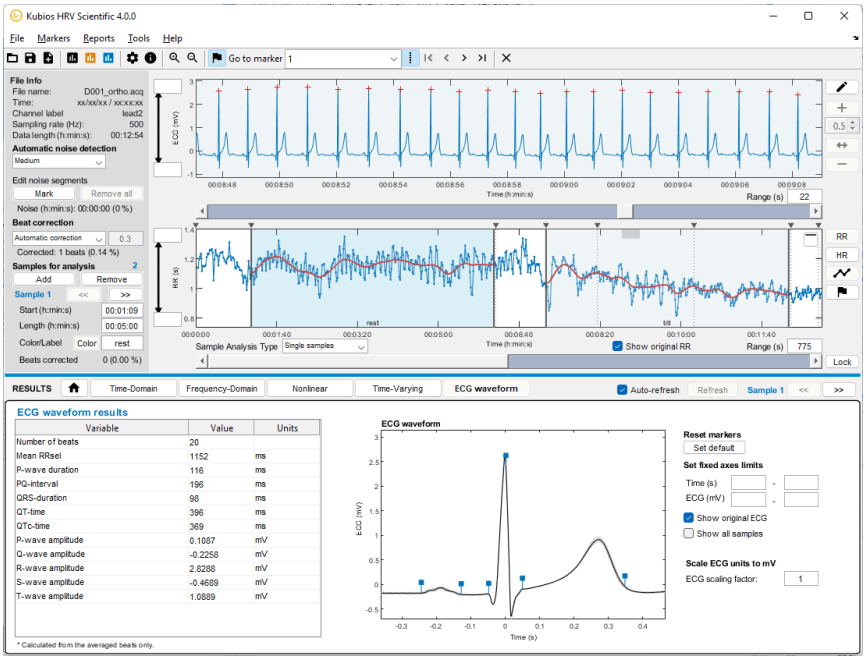
Polar H10 heart rate sensor

Elite HRV Mobile App



Kubios HRV Scientific Lite



Appendix F

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Set-up and Measurement Instructions

The impact of a 10-session online breathing intervention on heart rate variability, mean heart rate, and anxiety in veterans: A multiple-baseline study.

Welcome to the study and thank you for your participation.

Below you will find instructions to help you set up, take daily HRV and Mean HR measurements, and complete a short daily questionnaire.

We understand that this study may be challenging, however we hope you find the breathing exercises and daily measurements both engaging and fun. This is an opportunity to explore your own physiological responses and learn first-hand how controlled breathing may impact your body and mind.

If you have any questions or concerns, please don't hesitate to reach out to Ben at (email link or contact details below).

Set-up

1. Download the Elite HRV (EHRV) mobile app (https://elitehrv.com/)
2. Follow the set-up instructions on the app and register your details.
3. Polar H10. Follow the instructions of wearing the strap and attach the sensor.
4. When wearing the H10, open the EHRV app – go to 'settings' (top right); 'Devices' and ensure that the device has paired with the app.

Taking a measurement

1. Put on the H10 and attach the sensor.
2. Open the EHRV append press the **+** symbol at the bottom of the screen.
3. Open 'Morning HRV reading' and change the time to 1 min.
4. Press 'Take Morning Readiness' and allow the app to connect to the H10. Let the live preview start measuring for anytime between 30secs and 1min.
5. Press 'Start Reading' to take the 1min measure.
6. On completion 'save' activity.

For the study.

1. You will be required to take a 'morning HRV reading', in a seated position, within 20mins of waking up. Ideally at the same time each morning, and before any stimulating activity including caffeine. Please use the bathroom first if required.

   (Recommended is to put the device next to your bed. On waking, move to a seated position and then go through the process of 'taking a measurement before starting your day. Whatever works best for you. Please ensure your measurement is consistent each day).

2. Once you have made your 1min recording, Go to the 'home tab' then 'settings' (top right of screen) and scroll down to 'export data' (this will send the data file to your registered email).

3. Please forward your email with the data file to bp90@students.waikato.ac.nz

4. Before starting your day, record on a notepad, or app, anything significant from the last 24 hours. Please put today's date, followed by a couple of words. For example – ill, had a cold, had a tough day at work, a long run, poor sleep, relationship issues, drinking etc. If nothing significant simply put 'nothing'. We'll ask you during the study and at the end to send a photo or screen shot of your activity log.

Daily Questionnaire

1. You will receive a daily questionnaire with 8-items, scaled 0 - 10, via email from Qualtrics.

2. You can complete this whenever is appropriate for you on that same day.

3. When answering the questions, try not to 'over think it'. There are no right or wrong answers. Aim to complete it withing 1 – 2 minutes.

Any issues then please email me, or use the resources found on the internet.

Ben Pointer (+64) 021 177 2387: bp90@students.waikato.ac.nz
Dr. Rebecca Sargisson (Supervisor) (+64) 022 070 2447: Rebecca.sargisson@waikato.ac.nz

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Appendix G

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Study Guide

The impact of a 10-session online breathing intervention on heart rate variability, heart rate, and anxiety in veterans: A multiple-baseline study.

Here is a guide that I hope you will find useful as a way of ticking off tasks throughout the study. Please feel free to use it as you wish.

Stage 1: Pre-study

- ☐ Completed screening questionnaire
- ☐ Completed an online consent form
- ☐ Completed initial online questionnaires x 4

Stage 2: Initial measurement stage

- ☐ Morning HRV recording
- ☐ Export results through the App to yourself, forward that email to Ben please.
- ☐ Daily questionnaire
- ☐ Daily activity log (any significant events over the last 24hours, otherwise 'none')

Continue at stage 2 until advised to move to stage 3.

Stage 3: Breathing program

- ☐ Complete each module of the breathing program daily
- ☐ Complete daily questionnaire on the day you complete the breathing
- ☐ Daily activity log (any significant events over the last 24hours, otherwise 'none')
- ☐ Export results to Ben when advised to do so.

When you have finished all 10 breathing sessions let me know. You have up to 20 days to complete them, so you have some flexibility to work around your life. (a nice way to do it is to complete 5, take a couple of days off, then complete the next 5). Please don't do more than 1 a day.

Stage 4: Completion.

Once you have let me know that you have completed, I will send you another round of 5 questionnaires

☐ Completed 5 online course completion questionnaires

Stage 6: Follow-up

You will receive another round of the same 5 questionnaires about 6-weeks after you have finished the course.

☐ Completed 5 online follow-up questionnaires

Study complete

If you have any issues at all please let me know. My contact details as below.

Feel free to use my personal email p.staff1976@gmail.com which I'll monitor daily, or use WhatsApp +64 (0)21 177 2387 if you find that easier. You can also let me know if you'd prefer a zoom call.

Ben Pointer, Master of Applied Psychology Researcher
School of Psychological and Social Sciences, University of Waikato, New Zealand: (+64) 021 177 2387:
bp90@students.waikato.ac.nz

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Appendix H

Daily Assessment of Symptoms – Anxiety (DAS-A)

(via Qualtrics: https://www.qualtrics.com/)

1. During the past 24 hours, on average, how anxious did you feel?

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

Not at all anxious Extremely anxious

2. During the past 24 hours, how anxious did you feel when you were the most anxious?

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

Not at all anxious Extremely anxious

3. During the past 24 hours, on average, how worried did you feel?

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

Not at all anxious Extremely anxious

4. During the past 24 hours, how much of the time did you feel tense (when you were awake)?

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

None of the time All of the time

5. During the past 24 hours, how irritable did you feel when you were the most irritable?

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

Not at all irritable Extremely irritable

6. During the past 24 hours, how much of the time did you feel calm or relaxed (when you were awake)?

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

None of the time All of the time

7. During the past 24 hours, how much of the time did you have trouble concentrating or focusing on what you were doing (when you were awake)?

☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10

None of the time All of the time

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Appendix I

General Anxiety Disorder – 7
GAD-7

(via Qualtrics: https://www.qualtrics.com/)

Over the last 2 weeks, how often have you been bothered by the following problems?

	Not at all	Several days	More than half the days	Nearly every day
1. Feeling nervous, anxious, or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it is hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid as if something awful might happen	0	1	2	3

Total score: _____

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Appendix J

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Positive and Negative Affect Schedule (PANAS)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to what extent you feel this way right now, that is, at the present moment OR indicate the extent you have felt this way over the past week (circle the instructions you followed when taking this measure)

1 Very Slightly or Not at All	2 A Little	3 Moderately	4 Quite a Bit	5 Extremely

_____ 1. Interested	_____ 11. Irritable
_____ 2. Distressed	_____ 12. Alert
_____ 3. Excited	_____ 13. Ashamed
_____ 4. Upset	_____ 14. Inspired
_____ 5. Strong	_____ 15. Nervous
_____ 6. Guilty	_____ 16. Determined
_____ 7. Scared	_____ 17. Attentive
_____ 8. Hostile	_____ 18. Jittery
_____ 9. Enthusiastic	_____ 19. Active
_____ 10. Proud	_____ 20. Afraid

Scoring Instructions:
Positive Affect Score: Add the scores on items 1, 3, 5, 9, 10, 12, 14, 16, 17, and 19. Scores can range from 10 – 50, with higher scores representing higher levels of positive affect. Mean Scores: Momentary = 29.7 (SD = 7.9); Weekly = 33.3 (SD = 7.2)

Negative Affect Score: Add the scores on items 2, 4, 6, 7, 8, 11, 13, 15, 18, and 20. Scores can range from 10 – 50, with lower scores representing lower levels of negative affect. Mean Score: Momentary = 14.8 (SD = 5.4); Weekly = 17.4 (SD = 6.2)

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Appendix K

Mindful Attention Awareness Scale (MASS)

(via Qualtrics: https://www.qualtrics.com/)

Almost always	Very frequently	Somewhat frequently	Somewhat infrequently	Very infrequently	Almost never
1	2	3	4	5	6

1. I could be experiencing some emotion and not be conscious of it until some time later.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
2. I break or spill things because of carelessness, not paying attention, or thinking of something else.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
3. I find it difficult to stay focused on what's happening in the present.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
4. I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
5. I tend not to notice feelings of physical tension or discomfort until they really grab my attention.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
6. I forget a person's name almost as soon as I've been told it for the first time.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
7. It seems I am "running on automatic" without much awareness of what I'm doing.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
8. I rush through activities without being really attentive to them.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
9. I get so focused on the goal I want to achieve that I lose touch with what I am doing right now to get there.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
10. I do jobs or tasks automatically, without being aware of what I'm doing.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
11. I find myself listening to someone with one ear, doing something else at the same time.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
12. I drive places on "automatic pilot" and then wonder why I went there.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
13. I find myself preoccupied with the future or the past.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
14. I find myself doing things without paying attention.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6
15. I snack without being aware that I'm eating.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6

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Appendix L

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Te Whare Wānanga o Waikato

Acceptance and Action Questionnaire - II
AAQ-II
(via Qualtrics: https://www.qualtrics.com/)

Below you will find a list of statements. Please rate how true each statement is for you by circling a number next to it. Use the scale below to make your choice.

1 never true	2 very seldom true	3 seldom true	4 sometimes true	5 frequently true	6 almost always true	7 always true

1. It's OK if I remember something unpleasant.	1	2	3	4	5	6	7
2. My painful experiences and memories make it difficult for me to live a life that I would value.	1	2	3	4	5	6	7
3. I'm afraid of my feelings.	1	2	3	4	5	6	7
4. I worry about not being able to control my worries and feelings.	1	2	3	4	5	6	7
5. My painful memories prevent me from having a fulfilling life.	1	2	3	4	5	6	7
6. I am in control of my life.	1	2	3	4	5	6	7
7. Emotions cause problems in my life.	1	2	3	4	5	6	7
8. It seems like most people are handling their lives better than I am.	1	2	3	4	5	6	7
9. Worries get in the way of my success.	1	2	3	4	5	6	7
10. My thoughts and feelings do not get in the way of how I want to live my life.	1	2	3	4	5	6	7

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Social Validity Questionnaire (via Qualtrics)

Please answer the following questions based on your experience with the breathwork practice.

5. Acceptability
   How acceptable do you think this breathwork practice is for veterans or police officers who may be hesitant to initially access traditional support services?

Scale:
1 = Not at all acceptable
5 = Completely acceptable

6. Understanding Behavioural Impact
   How much has this experience helped you understand how behaviours like poor sleep, alcohol use, or disrupted routines can affect your body's stress response (e.g., as shown in HRV)?

Scale:
1 = Not at all
5 = Extremely

7. Confidence with Technique
   How confident are you that you followed the breathwork technique correctly using the video instructions?

Scale:
1 = Not confident at all
5 = Very confident

8. Recommendation
   How likely are you to recommend this practice to other veterans or police officers?

Scale:
1 = Not at all likely
5 = Extremely likely

9. Sustainability
   How likely are you to continue using this breathwork practice on your own after the study?

Scale:
1 = Not at all likely
5 = Extremely likely

10. Final Comments
    Was there anything that made it difficult to complete the breathwork sessions, or anything else you'd like to share about your experience?

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Appendix N

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Te Whare Wānanga o Waikato

Consent Form

(via Qualtrics: https://www.qualtrics.com/)

The impact of a 10-session online breathing intervention on heart rate variability, mean heart rate, and anxiety in veterans: A multiple-baseline study.

Please complete the following checklist. Tick (ü) the appropriate box for each point.	**Yes**	**No**
1. I have read the Participant Information Sheet, and I understand my role and responsibility in this study.		
2. I have been given sufficient time to consider whether or not to participate in this study.		
3. I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without penalty.		
4. I have the right to decline to participate in any part of the research activity.		
5. I know who to contact if I have any questions about the study in general.		
6. I understand that my participation in this study is confidential and that no material, which could identify me personally, will be used in any reports on this study.		
7. I confirm that I do not suffer from any medical conditions outlined that may increase the adverse symptoms of breathwork nor under the psychological care.		
8. I would like to receive a summary of the study's findings.		

Declaration by participant:
I agree to participate in this research project, and I understand that I may withdraw at any time. If I have any concerns about this project, I may contact the convenor of the Psychology Research and Ethics Committee.

Participant's name (Please print):

Signature: Date:

Declaration by member of research team:
I have given a verbal explanation of the research project to the participant and have answered the participant's questions about it. I believe that the participant understands the study and has given informed consent to participate.

Researcher's name (Please print)

Signature: Date

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Appendix O

Contact List

If you require any assistance please use the following contacts:

Ben Pointer (+64) 021 177 2387: bp90@students.waikato.ac.nz

Dr. Rebecca Sargisson (Supervisor) (+64) 022 070 2447: Rebecca.sargisson@waikato.ac.nz

Royal Marines Association RMA Request Help - RMA - The Royal Marines Charity (rma-trmc.org) These referrals will be responded to on our return.

If your need is urgent, please contact one of the relevant charities listed below:

The Samaritans T: 116 123,

Veterans Support Hub: 0808 175 3075 W: www.samaritans.org.uk

Combat Stress T: veterans - 0800 138 1619, serving - 0800 323 4444
W: www.combatstress.org.uk

SSAFA T: 0800 731 4880 W: www.ssafa.org.uk

The Royal British Legion T: 0808 802 8080 W: www.britishlegion.org.uk

If you are in a life-threatening situation, please call 999 immediately or go to the nearest Accident & Emergency Department.

If your issue is a non-urgent medical problem, you should contact your GP or call NHS 111.

Appendix P

Raw Heart Rate Results (BPM)

	Group 1				Group 2			
Day	P1	P2	P3	P4	P5	P6	P7	P8
1	73.358	69.433	47.317	60.914	67.349	51.042	62.66	81.406
2	75.373	80.776	64.43	55.467	59.598	56.943	66.138	84.952
3	76.033	80.017	48.161	63.664	56.136	55.089	63.729	84.11
4	78.484	68.605	46.57	64.195	59.301	55.366	61.81	90.7
5	73.801	62.615	50.889	58.574	59.878	54.027	63.619	91.426
6	67.237	65.913	46.787	55.085	62.392	61.674	69.673	90.352
7	69.978	68.741	52.718	60.756	62.706	51.621	68.441	86.937
8	68.998	72.771	52.357	59.906	64.079	51.433	65.447	82.481
9	83.654	66.509	52.236	59.231	71.781	52.354	77.026	87.527
10	84.014	66.905	45.417	66.862	60.067	56.127	87.922	87.406
11		67.514	50.83	52.722	55.445	60.462	78.008	89.198
12	103.47		55.581	63.529	57.054	50.879	74.457	92.733
13	79.264	67.744	53.874	68.454	61.143	50.892	65.635	90.948
14	84.253	57.42	55.363	50.302	62.292	52.172	62.014	84.633
15	70.789	61.827	52.297	50.444	65.434	52.504	72.618	81.14
16	70.662	60.362	49.78	50.816	62.574	52.892	71.489	82.505
17	84.433	71.12	51.008	52.059	63.753	59.521	74.581	83.04
18	70.587	77.175	50.864	55.963	58.578		64.638	81.478
19		73.335	53.607	54.843	60.044		68.214	87.384
20	74.464	66.401	51.125	53.031	74.308	58.877	64.248	88.401
21	72.505	70.921	50.789	64.367	59.89	54.536	70.506	86.575
22	68.459	63.885	54.696	59.807	61.628	58.617	95.405	84.13
23	73.928	64.369	52.001	49.643	57.78	61.557	89.659	86.173
24	71.759	71.142	54.856	70.565	60.573	60.682	91.436	81.328
25	70.363		51.066	56.29	65.028	60.083	80.001	92.739
26	70.379		53.9	61.11	59.343	56.281	75.718	85.555
27	68.513		54.521	57.485	64.071	67.188	75.507	94.874
28	76.467			65.266	58.835	64.212	80.13	88.177
29			69.628	61.019	54.64	56.448	65.008	82.541
30			65.552	62.989	58.236	55.278	74.122	83.304
31			63.046	55.364	60.62	47.628	67.423	8.8364
32			53.239		62.819	57.113	78.273	81.195
33					66.518	63.246	74.684	83.165
34						64.086		86.15

Note. Line __ denotes change of phase from baseline, intervention and follow-up.