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A Mixed-Methods Feasibility Study on the Effects of Breathing Exercises and Cold Exposure on Positive and Negative Affect


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**Abstract**

High-ventilation breathing with retention (HVBR) and cold-water exposure (CWE) have gained popularity in recent times, yet rigorous evidence for their psychological effects remains limited. This mixed-methods feasibility study examined the acute and short-term effects of self-administered HVBR, CWE, and mindfulness on affect, depressive symptoms, and anxiety, while evaluating the viability of the study protocol for a larger-scale randomized controlled trial. Fifteen participants (mean age = 30 years, 26.7% female) started the 4-week protocol. In weeks 1 and 2, participants were randomly assigned to perform either breathwork or cold showers alone (counterbalanced in week 2). In week 3, both practices were combined, and in week 4, an explicit mindfulness component was added. Positive affect (PA) and negative affect (NA) were assessed pre- and post-intervention each session. Qualitative questionnaires captured subjective experiences, protocol adherence, and adverse effects. Significant reductions in NA and increases in PA were observed from pre- to post-intervention across all four weeks. Cold showers produced significantly greater PA increases than breathwork alone, while both interventions reduced NA comparably. Mean compliance was 83.3%, and adverse effects were generally mild and consistent with known physiological responses. Most participants reported no perceived effect of the mindfulness component, which may indicate that these practices inherently cultivate mindful states. The findings suggest that HVBR and CWE produce robust acute affective improvements and that the protocol is viable for self-administration in home settings. A larger-scale study is warranted to establish the effectiveness and mechanisms of these interventions as accessible mental health tools.

*Keywords:* breathwork, cold-water exposure, Wim Hof Method, feasibility study, mixed methods

**Zusammenfassung**

Hyperventilationsatmung mit Atemanhalten (HVBR) und Kaltwasserexposition (CWE) haben in jüngster Zeit an Popularität gewonnen, doch Belege für ihre psychologischen Effekte sind nach wie vor begrenzt. Diese Mixed-Methods-Machbarkeitsstudie untersuchte die akuten und kurzfristigen Effekte von HVBR, CWE und Achtsamkeit auf Affekt, depressive Symptome und Angst und evaluierte gleichzeitig die Durchführbarkeit des Studienprotokolls für eine größer angelegte randomisierte Kontrollstudie. Fünfzehn Teilnehmende (Durchschnittsalter = 30 Jahre, 26,7 % weiblich) begannen das vierwöchige Protokoll. In Woche 1 und 2 wurden die Teilnehmenden randomisiert einer alleinigen Atemübung oder einer alleinigen kalten Dusche zugewiesen (Wechsel der Intervention in Woche 2). In Woche 3 wurden beide Praktiken kombiniert, und in Woche 4 wurde eine explizite Achtsamkeitskomponente hinzugefügt. Positiver Affekt (PA) und negativer Affekt (NA) wurden vor und nach jeder Interventionsdurchführung erhoben. Qualitative Fragebögen erfassten subjektive Erfahrungen, Protokolleinhaltung und unerwünschte Wirkungen. Über alle vier Wochen hinweg zeigten sich signifikante Reduktionen des NA und Anstiege des PA von prä- zu post-Intervention. Kalte Duschen zeigten signifikant stärkere PA-Anstiege als Atemübungen allein, während beide Interventionen NA vergleichbar reduzierten. Die durchschnittliche Compliance betrug 83,3 %, und unerwünschte Wirkungen waren überwiegend mild und entsprachen typischen physiologischen Reaktionen. Die meisten Teilnehmenden berichteten keinen wahrgenommenen Effekt der Achtsamkeitskomponente, was darauf hindeuten könnte, dass diese Praktiken inhärent achtsame Zustände fördern. Die Ergebnisse legen nahe, dass HVBR und CWE robuste akute affektive Verbesserungen bewirken und dass das Protokoll für eine selbstständige Durchführung geeignet ist. Eine größer angelegte Studie ist erforderlich, um die Wirksamkeit und Mechanismen dieser Interventionen als zugängliche Methoden zur Förderung der psychischen Gesundheit zu untersuchen.

*Keywords*: Atemarbeit, Kaltwasserexposition, Wim-Hof-Methode, Machbarkeitsstudie, Mixed-Methods-Forschung

**Contents**

**A Mixed-Methods Feasibility Study on the Effects of Breathing Exercises and Cold Exposure on Positive and Negative Affect**

For thousands of years, a wide variety of breathing techniques have appeared throughout human history (Fitzgerald & Cherniack, 2012). Similarly, hydrotherapy (application of water to the body for positive health outcomes) has a long history with recorded uses in ancient cultures like China, Egypt, India, and Persia (Muir, 1998). In recent times a combination of both practices was developed and popularized by Wim Hof as a practice that is “designed to be used by anybody” while claiming many health benefits including increased energy and reduced stress levels (Hof, 2018). The Wim Hof Method (WHM) consists of multiple rounds of deep breathing and alternating breath holds, cold-water exposure and mindset/commitment (Hof, 2018). A study by Kopplin and Rosenthal (2023) suggests that the combination of such breathing techniques and cold exposure compared to either exercise on their own may exhibit positive complementary effects at least on participants perceived stress. While initial studies have found some promising effects of the WHM (Buijze, 2019; Kox et al., 2012, 2014; Muzik et al. 2018; Petraskova, 2022; Zwaag, 2020) those were methodically limited and merit no generalizable conclusions. A single-group study by Faid et al. (2022) with a 10-day longitudinal intervention design found preliminary evidence that the WHM elicits improvements in symptoms of well-being, stress, and depression in 39 healthy participants. In contrast to these results, in a randomized controlled trial (RCT) by Ketelhut et al. (2023), 42 healthy males either performed the WHM daily or did not engage in any exercise for 15 days. No significant time × group interactions or group effects on cardiovascular and psychological parameters were found, including heart rate variability, perceived stress, positive and negative affect, and subjective trait and state vitality. However, it should be noted that the sample could have been too small to detect significant effects. A RCT by Blades et al. (2024) with 84 highly depressed women found that three weeks of daily WHM practice reduced depressive symptoms, anxiety, and perceived stress to a similar degree as a slow-paced breathing and warm shower control condition. A recent semi-randomised controlled trial with 404 participants by Fox et al. (2025) compared three conditions: WHM in-person, WHM-remote, and mindfulness meditation. The study found greater improvements in self-reported energy, mental clarity, and ability to handle stress following the daily protocol over 29

days for the WHM conditions compared with meditation. The impact of WHM on those measures and on self-reported state stress increased over the intervention period, suggesting accumulative benefits (Fox et al., 2025). Across pre–post measures including depression, sleep quality, and stress, consistent within-condition improvements were observed. Between-condition differences were mostly absent, except that the WHM group had a significantly lower breathing rate and resting heart rate relative to the meditation group, pointing to potential physiological benefits.

**Breathing exercises**

Breathwork comprises various practices, particularly to promote mental, emotional and physical health (Oxford University Press, 2026) by consciously overriding the automatic breathing mechanism (Zaccaro et al., 2018). A meta-analysis by Fincham et al. (2023) on the effects of breathwork in 785 participants from 12 RCTs found small-to-medium effect sizes for reducing stress, anxiety, and depressive symptoms. Ten studies comprised interventions focusing on slow-breathing, and two on faster-paced breathing. Other recent meta-analysis looking at slow deep breathing (SDB) found that the exercises may reduce acute pain intensity (Joseph et al., 2022), increase heart-rate-variability (HRV) (Gholamrezaei et al., 2021; Laborde et al., 2022; Shao et al., 2024), reduce systolic blood pressure and heart rate (Shao et al., 2024; Zou et al., 2017).

Less research has investigated the physiological and psychological effects of high ventilation breathwork (HVB) with retention (HVBR) exercises as used in the WHM. Physiologically HVB is characterized by the increase of the breathing rate above the healthy adult average of 14 breaths per minute (Ragnarsdóttir & Kristinsdóttir, 2006). The result is the increased elimination of $CO_2$ and simultaneous sympathetic activation (Fincham et al., 2023; Schüttler et al., 2020) affecting the hypothalamic-pituitary-adrenal (HPA) axis which mediates stress responses and cortisol levels (Abelson et al., 2010). Additionally, the elimination of $CO_2$ leads to respiratory alkalosis and elevated pH levels which prompts various subsequent effects that alter central nervous system functions (Fincham et al., 2023) including increased cerebral neuronal excitability (Han et al., 2015) and reduced cerebral blood flow (Brian, 1998). These mechanisms may underlie the psychophysiological effects of HVB (Fincham et al., 2023). Typical symptoms associated with respiratory alkalosis and hyperventilation are dizziness, palpitations, tingling of the extremities (Rapee et al., 1992), light-headedness, visual disturbances, and tinnitus (Posse et

al., 1997). The breath retention phase (apnea) between high ventilation phases within the WHM leads to a build-up of $CO_2$ in the blood, sympathetic activation (Bhandari et al., 2020) and initiates what is known as the “diving response” which includes a slowed heart rate, narrowing of peripheral blood vessels, elevated blood pressure, and splenic contraction (Foster & Sheel, 2005). As suggested by Fincham et al. (2023), such HVBR exercises may allow individuals to voluntarily engage in stressful experiences which may lead to better long-term mental health outcomes through hormesis (Calabrese & Mattson, 2017), characterized as an adaptive response where an organism becomes more resilient after exposure to temporary stressors (Faye et al., 2018; Mattson, 2008).

**Cold Water Exposure**

Cold water exposure (CWE) involves immersing the body partially or fully in cold water for different durations, in temperatures usually ranging from -2 to 20°C (Espeland et al., 2022). While a meta-analysis about CWE after exercise has demonstrated it can speed up the recovery of physiological processes, reduce post-exercise inflammation, and decrease muscle soreness (Moore et al., 2022) less is known about its effects and proper use for general psychophysiological health outcomes (Cain et al., 2025). A recent review and meta-analysis by Cain et al. (2025) found significant impacts of CWE on inflammation, stress, immunity, quality of life, and sleep. However, most studies in the meta-analysis lack follow-up data, depend on single-sessions, and have small sample sizes which makes it difficult to derive explicit conclusions about its effectiveness.

On a physiological level, the primary response to CWE is characterized by sympathetic activation including elevated norepinephrine levels, systolic blood pressure and HPA-axis mediated cortisol responses (Briganti et al., 2023; Cain et al., 2025; Janský et al., 1996; Wittert et al., 1992). Through baroreceptor feedback mechanisms the autonomic nervous system then gradually shifts to an increased parasympathetic activation (Lundell et al., 2020; Wittert et al., 1992). Additionally, elevated concentrations of dopamine (Šrámek et al., 2000) and beta-endorphins (Suzuki et al. 2007) have been reported after CWE which are both linked to improved mood (Jain et al., 2019; Radwan et al, 2019). Tripton et al. (2017) suggest that CWE could reduce inflammatory responses and consequently reduce symptoms of depressive disorders.

Similarly, as with HVBR, CWE represents a short and temporary stressor that may protect long-term against chronic stress through hormesis (Calabrese & Mattson, 2017; Wan et al., 2024). As suggested by Fox et al. (2025), on a metacognitive level CWE (and HVBR) may facilitate the capacity to effectively cope with stress since the successful confrontation with such experiences may adjust and increase the brain's assumptions about its self-regulation capacity (Stephan et al., 2016). Haas (2024) proposes an additional "mental reset mechanism" of CWE that works by cold receptors within the skin sending electric impulses to the brain (Shevchuk, 2008) which might stop excessive thinking, and negative affect for a while (Haas, 2024).

**Mindfulness**

As outlined by Haas (2024), the mindset/commitment component of the WHM partly overlaps with mindfulness as conceptualized in Baer et al.'s (2006) five-facet model, particularly the facets of observation (attending to one's thoughts, emotions, and bodily sensations), nonjudgment, and non-reactivity (sustaining emotional stability). Practicing mindfulness while exposed to a stressor like CWE without resisting to it may facilitate a "stress-is-enhancing mindset" which has been linked to greater positive affect and improved cognitive flexibility (Crum et al., 2017). In a meta-analysis by Vøllestad et al. (2012) mindfulness- and acceptance-based interventions (MABIs) under comfortable conditions were associated with reductions in symptoms of anxiety and depressive symptoms. The practice of mindfulness under extreme conditions may translate to a greater capacity for dealing with unpleasant stimuli in daily life (Haas, 2024).

**Feasibility Study**

The goal of a feasibility study (in contrast to a pilot study) is to test the viability of a given paradigm or project while also contributing more broadly to the base of knowledge in the field by the explicit plan to disseminate its results (Green et al., 2019). This study tests the feasibility of the planned RCT by Haas (2024), which examines the effectiveness of breathing exercises, cold showers, and mindset instructions in reducing symptoms of depression, anxiety, and posttraumatic stress disorder (PTSD) under real-life conditions. Rather than focusing primarily on clinical outcomes, this study places greater emphasis on participants' acute affective responses and experiences during the interventions using a mixed-methods approach assessing both quantitative outcomes — including affect, depression, and

anxiety — and participants' subjective experiences of the interventions. The aim is to identify areas for refinement in preparation for the larger-scale study, with a particular focus on compliance, clarity of instructions, and adverse side effects. Given the promising but methodologically limited evidence base, and the limited number of studies examining self-administered HVBR and CWE combined with mindfulness in naturalistic home settings, this feasibility study provides a necessary foundation for a rigorous large-scale investigation of these practices as widely accessible mental health interventions.

## Method

### Participants

Recruitment for the study was primarily done via social media platforms. An online document was sent out with relevant information about study procedure, duration, physiological and psychological requirements and a link to a pre-screening questionnaire. The pre-screening was done on SoSci Survey **(**https://sosci.univie.ac.at/) and included questions about demography, language fluency in English, previous experiences with breathing exercises or cold exposure, physical or mental impairments and if the study protocol will be conducted in Vienna (concerning the water temperature). Inclusion criteria were age 18 to 60, no relevant physical or psychological impairments (see Appendix A for contraindications), fluency in English (instruction videos were in English), any level of previous expertise with those exercises and the willingness to refrain from these exercises 1 week prior to the start of the study. Recruitment started on December 16, 2024 and ended on February 23, 2025. The participants could individually start their 4-week study protocol on a weekly basis beginning on January 20, 2025 with the last possible start on February 24, 2025. The last questionnaires were sent out on March 24, 2025. All subjects gave their written informed consent prior to participation in the study. This is a feasibility study with a study protocol that has an ethics approval by the University of Vienna.

21 participants filled out the pre-screening questionnaire and were eligible for the study. 15 participants completed at least one week of the study protocol and were included in the analyses. The average compliance of the participants was 83.3% for the prescribed minimum of intervention times (at least two practice days in week 1 and 2, and at least one day in week 3 and 4). The mean age of participants was 30 years with 26.7% females. 60% of participants had a university degree and 86.7%

had prior breathwork and cold exposure experience (see Appendix B for detailed characteristics of participants).

**Materials**

Positive Affect (PA) and Negative Affect (NA) as measured by the German and English short form version of selected items of the Positive and Negative Affect Schedule (PANAS; Breyer & Bluemke, 2016). This was measured by asking participants 'Please indicate how you feel in this moment.' in relation to following items: distressed (NA), anxious (NA), nervous (NA), ashamed (NA), guilty (NA), alert (PA), and excited (PA) (on a scale of 1-5, 1 being 'not at all', 2 being 'a little', 3 being 'moderately', 4 being 'quite a bit' and 5 being 'extremely'). The items for the NA scale were selected because they were thought to best reflect the research interests of the main study - anxiety, depression and post-traumatic stress (Haas, 2024). Two items for the PA scale were selected to minimize participants' load and because those items were thought to best reflect the described effects of the interventions. PA and NA scores were calculated as the mean of the respective items. As only a custom selection of items was used rather than a validated subscale of the PANAS, the published psychometric properties of the full instrument do not directly apply to this subset. Given the small sample size, internal consistency was not computed for the current data.

Anxiety Disorder as measured by the German (Löwe, 2015) and English (Spitzer, 2006) version of the Generalized Anxiety Disorder Scale-7 (GAD-7). This was measured by asking participants, 'how often have you been bothered by the following conditions over the past 2 weeks?' in relation to nine specific items (with the following 4 options: Not at all, Several days, More than half the days, Nearly every day). The GAD-7 has demonstrated high internal consistency (α = .92) and test-retest reliability (Löwe, 2015).

Depressive Disorder as measured by the German (Löwe, 2015) and English (*Kroenke,2001)* version of the Patient Health Questionnaire-9 (PHQ-9). This was measured by asking participants, 'how often have you been bothered by the following conditions over the past 2 weeks?' in relation to nine specific items (with the following 4 options: Not at all, Several days, More than half the days, Nearly every day). The PHQ-9 has demonstrated high internal consistency (α = .86- .89) and test-retest reliability (Kroenke et al., 2001).

“Shower Coldness” by asking the participants ‘How cold did you set the shower?’ on a scale of 1 to 3 (with 1 being ‘cool’, 2 being ‘cold and 3 being ‘very cold’).

“Shower (Un)Pleasantness” by asking the participants ‘How did you experience the cold water?’ on a scale of 1 to 11 (with 1 being ‘highly pleasant, 6 being ‘neutral’ and 11 being ‘highly unpleasant’).

Four different qualitative questionnaires were administered in German or English, tailored to the week and intervention type: cold shower, breathing exercise, breathing exercise combined with cold shower, and breathing exercise combined with cold shower and mindfulness. Claude 4.6 Sonnet (Anthropic, 2025) was used for translating questionnaires from German to English.

All questionnaires included the following items: (1) intervention frequency during the week (range: 1–7 times), (2) reasons for performing the intervention less or more than the recommended times (if applicable), (3) clarity of video/audio instructions, (4) adherence to the intervention protocol and any deviations, (5) personal experiences with the intervention(s), (6) specific strategies or timing chosen for the exercises, and (7) additional observations or comments.

The breathwork questionnaire included an additional item (8) assessing whether participants performed a nasal rinse and their experience with it (if applicable).

In Week 3, an additional item was included to (9) assess perceived differences in cold showering compared to the previous week when participants first completed the cold shower intervention.

In Week 4, two additional items were included: (10) uncertainties regarding the mindfulness exercise instructions, and (11) perceived differences in experience compared to Week 3 (without the mindfulness component).

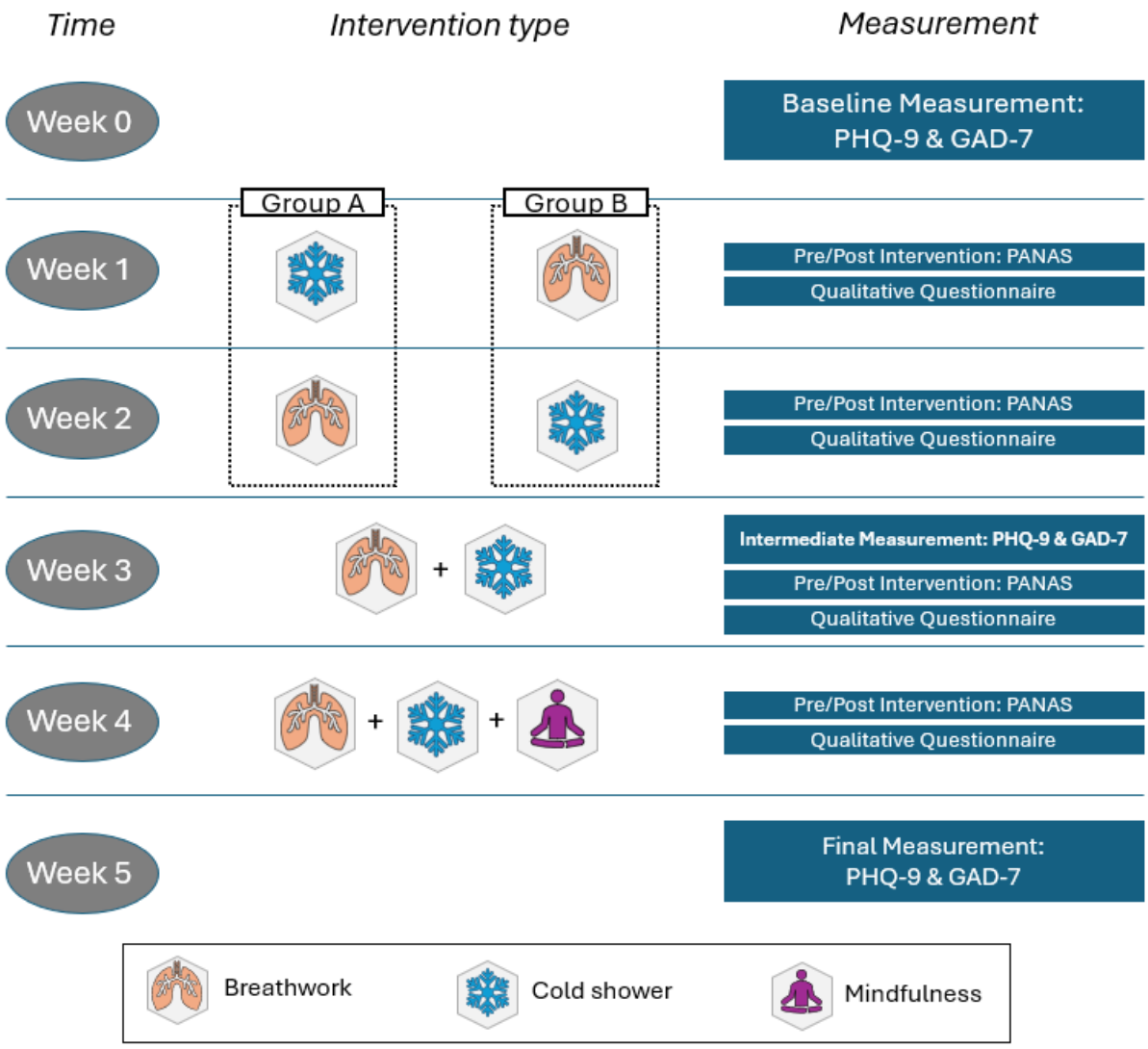
**Procedure**

The 4-week study protocol (see Figure 1) started with a baseline measurement of the participants’ depression and anxiety levels. The communication with the participants was done via email on the first day of each week (Monday). Before any instructions, participants were sent an introduction video explaining the basic procedure of the study including physiological and psychological benefits of the practices and a safety disclaimer. The participants were randomly assigned to either group A or group B. In week 1 group A was instructed to do only the cold shower at

least two times using a video explaining the process. Group B was instructed to do only the breathing exercise at least two times using a video explaining the process.

**Figure 1**

*Overview of the Study Design (N = 15)*




*Note.* In week 1 and 2 there were two groups (A and B) with a different intervention type. In week 3 and 4 every participant did the same intervention type.

Before and after each intervention they were instructed to fill out an online questionnaire using a subset of PANAS items. Additionally, for each cold-water intervention there was a questionnaire assessing the subjective water temperature and water (un)pleasantness. In each week there was an online document sent out with a specific qualitative questionnaire that the participants could fill out until the beginning of the next week. In week 2 group A was instructed to do the breathing

exercise at least two times and group B was instructed to do the cold shower at least two times. Week 3 started with an intermediate measurement of the participants' depression and anxiety levels. They were then instructed to first do the breathing exercise and then take the cold shower - at least one time - using two videos explaining the process. In week 4 the participants were sent an introduction video about mindfulness. They were then instructed to first do the breathing exercise and subsequently take the cold shower at least one time both with the additional mindfulness component integrated in the instruction videos. After completing week 4 there was a final measurement of the participants' depression and anxiety levels.

***Interventions***

An instruction video by Haas (2024) for the breathing exercise was privately uploaded to YouTube (https://www.youtube.com) and sent to the participants via email. The video was 17:39 minutes long and consisted of four rounds of breathing each containing three phases. The first phase consisted of breathing with 40 deep active inhalations preferably through the nose and passive exhalations preferably though the mouth. In the second phase the participants were instructed to exhale fully and hold the breath for 30 seconds in the first round and longer each round up to 120 seconds in the fourth. In the third (recovery breath) phase the participants were instructed to inhale fully and hold the breath for 15 seconds completing one round.

An instruction video by Haas (2024) for the cold shower was privately uploaded to YouTube and sent to the participants via email. The video was 8 minutes long and guided the participants through a sequential immersion with the cold water. First, each participant was instructed to set the water as cold as possible and start watering their legs then arms and finally the torso. Subsequently, the shower is turned off, and the participants may soap their bodies. Then, the head is watered, and the prior procedure is repeated. Finally, the whole body is showered completing the process.

An introduction video and updated instruction videos by Haas (2024) for the mindfulness component were privately uploaded to YouTube and sent to the participants via email. The introduction video was 5:06 minutes long and explained the benefits and applications of mindfulness during the practices. An emphasis was placed on developing a positive attitude towards the CWE by suggesting the opportunity to practice mindfulness under extreme conditions and by learning how to

stay calm under the cold water (being aware of oneself, not judging one´s own sensations, and not reacting to negative emotions).

***Statistical analyses***

All statistical analyses were conducted using R version 4.4.0 (R Core Team, 2024). R packages used for statistical analysis and data visualization were tidyverse (Wickham et al., 2019), car (Fox & Weisberg, 2019), rstatix (Kassambara, 2025), ez (Lawrence, 2026), effsize (Torchiano, 2020), emmeans (Lenth & Piaskowski, 2026), ggrain (Allen et al., 2021), magrittr (Bache & Wickham, 2025), ggplot2 (Wickham, 2016), gridExtra (Auguie, 2017), readxl (Wickham & Bryan, 2025), and patchwork (Pedersen, 2025). Claude 4.6 Sonnet (Anthropic, 2025), a generative artificial intelligence (AI) tool, was used for creating and refining R code.

Outliers have been winsorized at the 5th and 95th percentiles (Hemmerich, 2018) due to normality assumption violation. After small adjustments, normality of distribution was assumed for all measurements in all weeks using Shapiro-wilk-test and Q-Q-plots. A significance level of $\alpha = .05$ was applied for all statistical tests. Effect sizes were calculated using Hedges' *g* for all mean difference comparisons (paired and unpaired *t*-tests). Partial $\eta^2$ was reported as the effect size for the repeated measures ANOVA.

To assess changes in negative affect (NA) and positive affect (PA), paired *t*-tests were conducted comparing pre- and post-intervention scores for each participant's first exercise completion of each week. All participants with measurements at these time points were included in the analysis. Additionally, a repeated measures ANOVA was performed to examine whether the magnitude of change in NA and PA scores differed across the four weeks. This analysis included only participants who completed measurements in all four weeks.

To calculate the effectiveness of the breathwork and cold shower interventions on NA and PA, unpaired *t*-tests were conducted to compare the intervention types (between-groups) during week 1 and 2. Paired *t*-tests were conducted for the within-group analysis.

For the PHQ-9 and GAD-7 scores, a repeated measures ANOVA was conducted to examine changes across three time points (baseline, Week 3, and Week 5) for all participants with complete data at these measurement occasions.

### *Qualitative Analysis*

The qualitative data was analysed using two complementary approaches depending on the research question. For feasibility and protocol evaluation questions, a directed content analysis approach was employed (Hsieh & Shannon, 2005), while participants' subjective experiences were analysed using conventional content analysis to allow themes to emerge inductively from the data.

The directed content analysis was guided by the following research questions: (a) Do participants comprehend the intervention instructions? (b) Do participants adhere to the study protocol? (c) What barriers or problems do participants encounter during the interventions? (d) What potential side effects or adverse experiences do participants report? (e) Was there a difference in the cold shower when the breathing exercise was done before? (f) Was there a difference in the exercises when the mindfulness component was introduced? (g) What strategies do the participants use? (h) At what specific time do the participants engage with the exercises? (i) Were there other relevant additional observations or comments? Participant responses were systematically coded, categorized and summarized according to these predetermined questions. Frequencies of specific issues were documented to assess the prevalence of indications across participants.

For the research question examining participants' subjective experiences with the interventions, a conventional/inductive content analysis approach was employed (Hsieh & Shannon, 2005) without the use of predetermined categories. Responses to open-ended questions about personal experiences were systematically read and initial codes were derived from the answers, with codes reflecting the participants' own language and descriptions where possible. Related codes were then grouped into categories, and categories were further organized into overarching themes. This process continued iteratively. Frequencies of specific issues were documented to assess the prevalence of indications across participants.

## Results

### Negative Affect

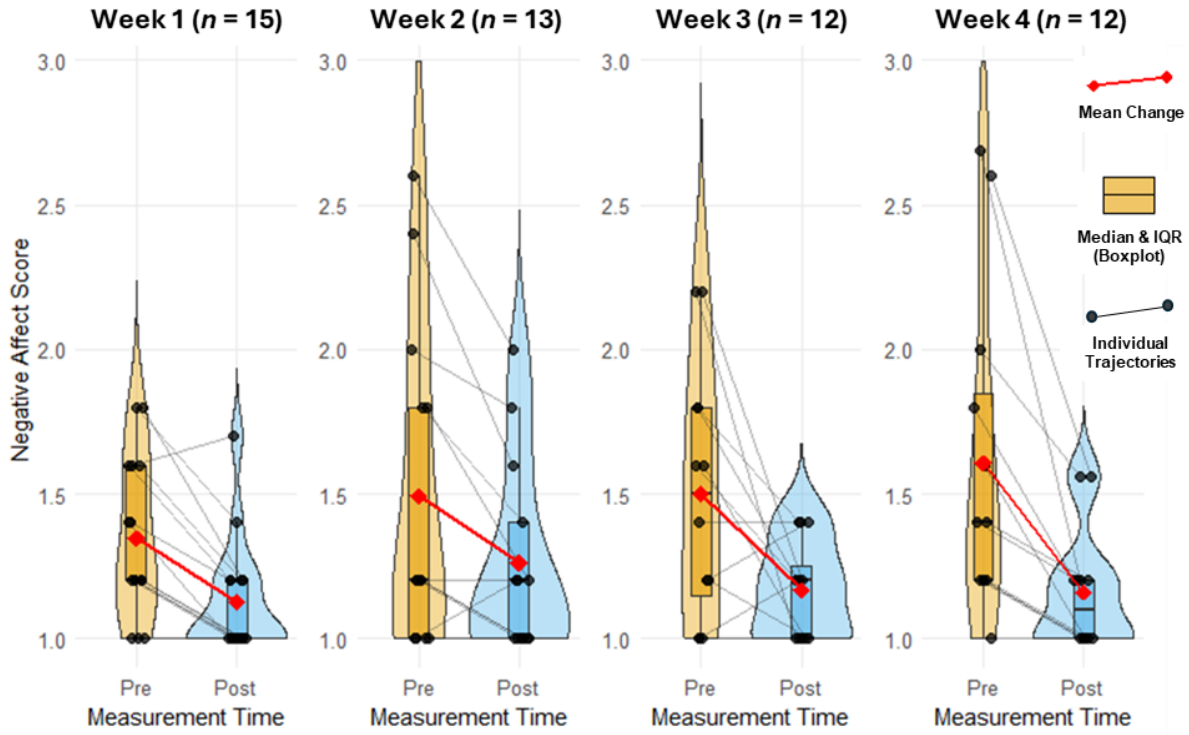
The analysis revealed statistically significant reductions in NA across all four weeks of the intervention protocol (see Figure 2). Two outliers have been winsorized in week 1 and 4 of NA. For the full description of data, including the second session of each week, see Table C1 in the Appendix C. In Week 1 ($N$ = 15), participants showed a significant decrease in NA from pre- to post-intervention, $t(14) = 4.40$, $p <$

.001, *g* = -0.81, 95% CI [-1.24, -0.38]. In Week 2 (*N* = 13), NA significantly decreased from pre- to post-intervention, *t*(12) = 2.84, *p* = .015, *g* = -0.32, 95% CI [-0.56, -0.08]. In Week 3 (*N* = 12), NA showed a reduction from pre- to post-intervention, *t*(11) = 2.54, *p* = .027, *g* = -0.92, 95% CI [-1.81, -0.03]. In Week 4 (*N* = 12), participants demonstrated the largest reduction in NA from pre- to post-intervention, *t*(11) = 3.59, *p* = .004, *g* = -0.70, 95% CI [-1.16, -0.25].

While descriptively there appears to be an increasing effect across sessions, a repeated measures ANOVA over all four timepoints for 12 participants found no statistically significant difference, *F*(3, 33) = 1.62, *p* = 0.203, partial η² = .13.

**Figure 2**

*Raincloud plot for Negative Affect Across* First Session of Each Week




*Note*. Raincloud plots use winsorized data. IQR = interquartile range. Violin plot (cloud) = data distribution.

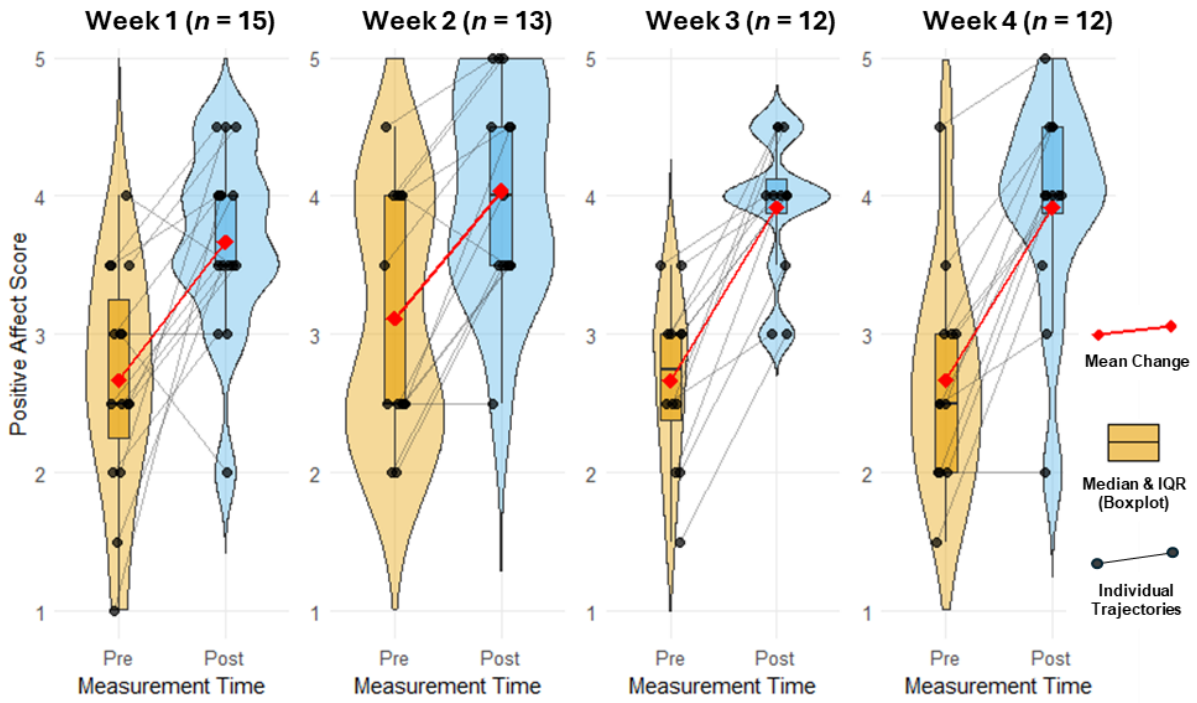
**Positive Affect**

There were statistically significant increases in PA for every week as shown in Figure 3 or Table C1 in the Appendix C. In Week 1 (*N* = 15), participants showed a significant increase in PA from pre- to post-intervention, *t*(14) = -3.74, *p* = .002, *g* =

1.26, 95% CI [0.34, 2.19]. In Week 2 (*N* = 13), PA significantly increased from pre- to post-intervention, *t*(12) = -4.95, *p* < .001, *g* = 1.02, 95% CI [0.50, 1.55]. In Week 3 (*N* = 12), PA showed a significant increase from pre- to post-intervention, *t*(11) = -7.42, *p* < .001, *g* = 2.04, 95% CI [1.04, 3.03]. In Week 4 (*N* = 12), PA increased significantly from pre- to post-intervention, *t*(11) = -6.27, *p* < .001, *g* = 1.45, 95% CI [0.76, 2.14].

**Figure 3**

*Raincloud Plot for Positive Affect Across First Session of Each Week*




*Note*. IQR = interquartile range. Violin plot (cloud) = data distribution.

While descriptively there appears to be an increasing effect across sessions, a repeated measures ANOVA over all four timepoints for 12 participants found no statistically significant difference, *F*(3, 33) = 0.81, *p* = 0.497, partial $\eta^2$ = .07.

**Breathwork versus Cold Shower**

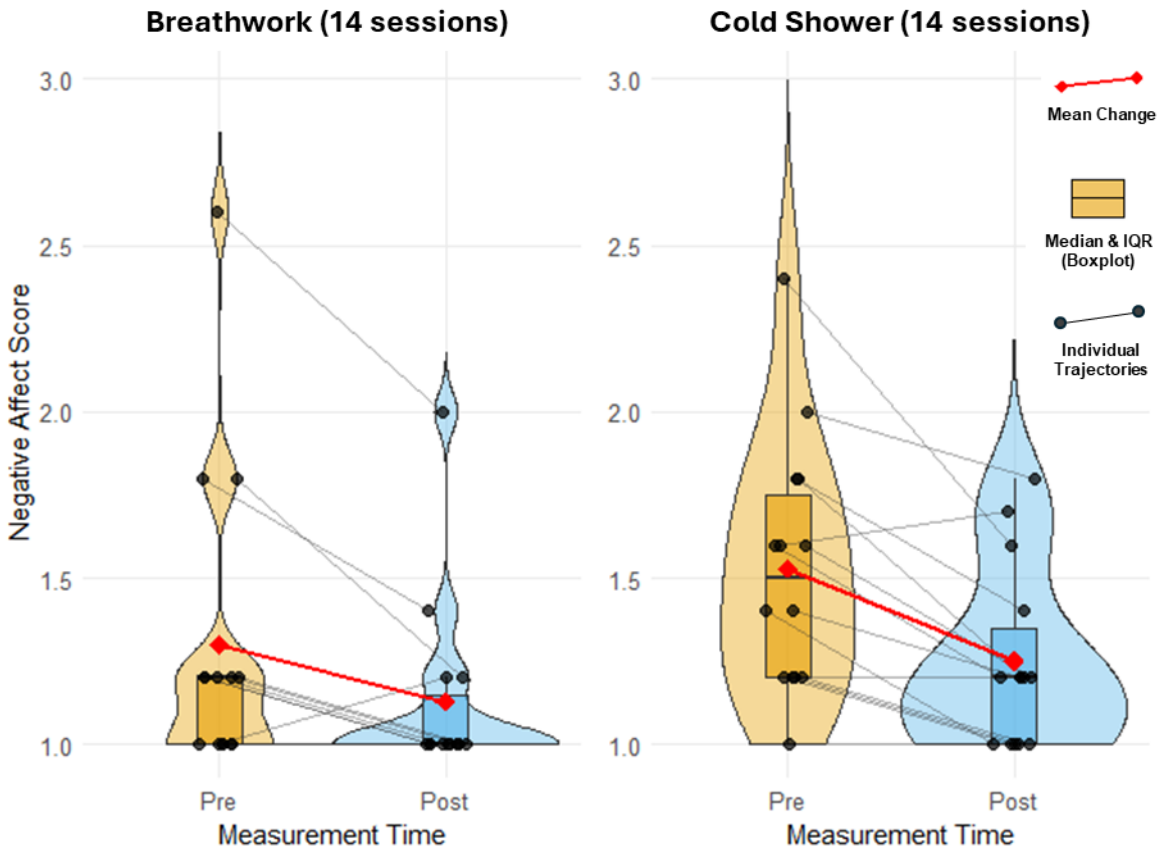
***Negative Affect***

Both interventions produced statistically significant reductions in negative affect (see Figure 4). For the full description of data see Table C2 in the Appendix C. Participants in the breathwork condition (*N* = 14) showed a significant reduction in negative affect, *t*(13) = -2.75, *p* = .0017, *g* = -0.28, 95% CI [-0.49, -0.07]. Participants

in the cold shower condition (*N* = 14) showed a significant reduction in negative affect, *t*(13) = -4.30, *p* < .001, *g* = -0.73, 95% CI [-1.12, -0.34].

**Figure 4**

*Raincloud Plot for Breathwork Versus Cold Shower on Negative Affect*




*Note.* Only first session in week 1 and 2 was included. Raincloud plots use winsorized data. IQR = interquartile range. Violin plot (cloud) = data distribution.

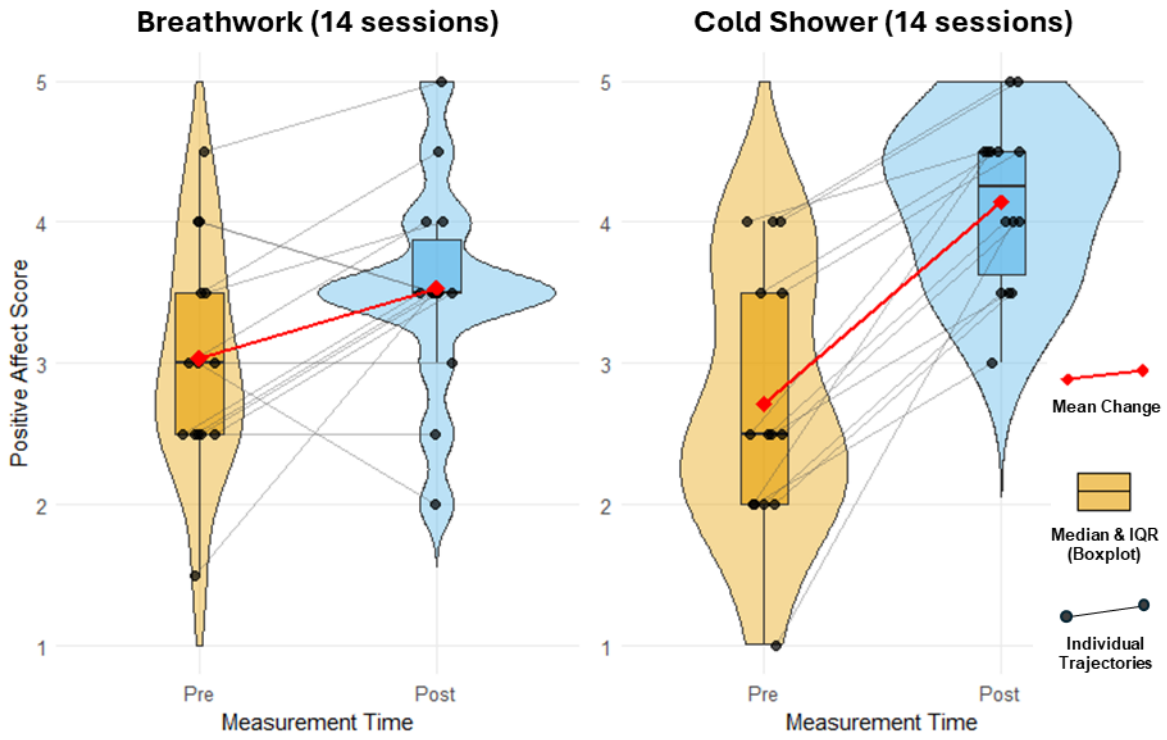
The between-group comparison revealed no statistically significant difference in the magnitude of NA change between the breathwork and cold shower interventions, *t*(26) = 1.19, *p* = .244, *g* = 0.44, 95% CI [-0.33, 1.20].

***Positive Affect***

Both interventions produced statistically significant increases in positive affect (see Figure 5 or Table C2). Participants in the breathwork condition (*N* = 14) showed a significant increase in positive affect, *t*(13) = 2.31, *p* = .038, *g* = 0.61, 95% CI [0.02, 1.20]. Participants in the cold shower condition (*N* = 14) showed a significant increase in positive affect, *t*(13) = 7.92, *p* < .001, *g* = 1.56, 95% CI [0.96, 2.16].

**Figure 5**

*Raincloud Plot for Breathwork Versus Cold Shower on Positive Affect*




*Note.* Only first session in week 1 and 2 was included. IQR = interquartile range. Violin plot (cloud) = data distribution.

The between-group comparison revealed a statistically significant difference in the magnitude of PA change between the two intervention types, $t(26) = -3.30$, $p = .003$, $r = .534$, $g = -1.21$, 95% CI [-2.03, -0.39]. The cold shower intervention produced a significantly greater increase in positive affect than the breathwork intervention.

**GAD-7 and PHQ-9**

Eleven participants completed assessments at all three time points (baseline, Week 3, and Week 5). One outlier in week 1 of the PHQ-9 and GAD-7 data has been winsorized. PHQ-9 scores showed a descriptive reduction from baseline ($M = 5.91$, $SD = 4.73$) to Week 3 ($M = 4.82$, $SD = 2.79$), with scores remaining relatively stable at Week 5 ($M = 4.73$, $SD = 3.17$). Similarly, GAD-7 scores decreased from baseline ($M = 5.63$, $SD = 3.90$) to Week 3 ($M = 3.73$, $SD = 2.72$), with a slight increase observed at Week 5 ($M = 4.36$, $SD = 2.38$).

For depressive symptoms, the repeated measures ANOVA did not reveal statistically significant changes in PHQ-9 scores, $F(2, 20) = 1.01$, $p = .383$, partial $\eta^2 = .09$. Similarly, changes in GAD-7 scores for anxiety symptoms were not statistically significant, $F(2, 20) = 2.15$, $p = .143$, partial $\eta^2 = .18$.

**Qualitative Results**

The study included 15 participants with everyone (100%) filling out the qualitative questionnaire in week 1, 12 (80%) in week 2, 12 (80%) in week 3 and 10 participants (66.7%) submitting the questionnaire in week 4. The volume of qualitative feedback provided by each participant varied considerably and every statement that was given was included in the analysis. It is worth mentioning that this introduces bias, so more indications do not necessarily mean that more people experienced it in this way, it could also mean that one participant expressed the sentiment in more weeks. Additionally, some questions that were not answered by a participant could have meant “no” or “don’t know/want to answer”, which complicated interpretation further and should be kept in mind when reading through the answers. When appropriate, percentages of participants answering in a certain way was given to establish some context. Only the most relevant answers are presented here, for a full overview of reports see Table D1 in Appendix D.

In response to the first question about participants ability to comprehend the instructions (a), everyone seemed to be able to follow the instructions.

There were a couple of deviations from the study protocol (b) as reported by the participants. Regarding the recommended number of sessions per week there were 12 indications about reasons for doing the intervention less often, including “no time” (4x), “sickness” (3x). In contrast there were almost no indications about doing it more frequently. Regarding deviations from the cold shower intervention itself, there were indications about “shorter/improvised pauses” (3x), “showering the whole body from the beginning on” (2x), and “taking an ice bath instead of a shower” (2x). For the breathing intervention, there were indications of performing the exercises in a lying position (4x) or using a different Wim Hof instruction video (1x).

Concerning the barriers or problems that participants faced (c) during the breathing exercise there were indications about “difficulty concentrating” (3x), “difficulty holding the breath” (2x), and “difficulty maintaining the breathing rhythm” (1x). For the cold shower intervention only, there were indications about it taking

“effort to do” (6x), “unpleasantness during the shower” (5x), and “inner resistance before shower” (2x).

Adverse experiences and negative side effects (d) consisted of “prolonged hypothermia after cold shower” (3x), “noise/tinnitus after breathing exercise” (2x) with one participant reporting that his existing tinnitus got temporarily worse and settled down again, “anxiety with a rapid heartbeat before going to bed” which was experienced by one participant after a scuba dive on the same day in the morning, “dizziness after breathing exercise” (1x), and “cramping of the body during breathing” (1x).

Regarding the difference in the cold shower when the two practices got combined in week 3 (e), eight participants (66.7%) of the 12 who submitted a questionnaire in this week reported more positive effects for the cold shower experience. There were indications about it being “more pleasant” (3x) and participants experienced “less resistance” and were “calmer” (2x). Some participants indicated the breathing helped to “heat their body” and to tolerate the cold.

Pertaining to differences experienced with the added mindfulness component (f), only two participants (20.0%) of 10 explicitly mentioned positive effects with the addition. Some participants explicitly indicated “no difference” (4x) to the question, while some indicated they “were already practising mindfulness in the weeks before” (2x).

When asked about specific strategies for doing the exercises (g), most participants didn’t answer this question. Some participants mentioned that “deep breathing” (2x) and “concentrating on the breath” (1x) during the shower helped them with the cold exposure.

When asked about the timing for doing the exercises (h), five participants (33.3%) explicitly and coherently stated they would do it in the morning, for the others it was more variable (see Figure A1 in appendix A).

Regarding other relevant observations or comments (i), three participants reported being on holiday for at least one week with water temperature not being that cold.

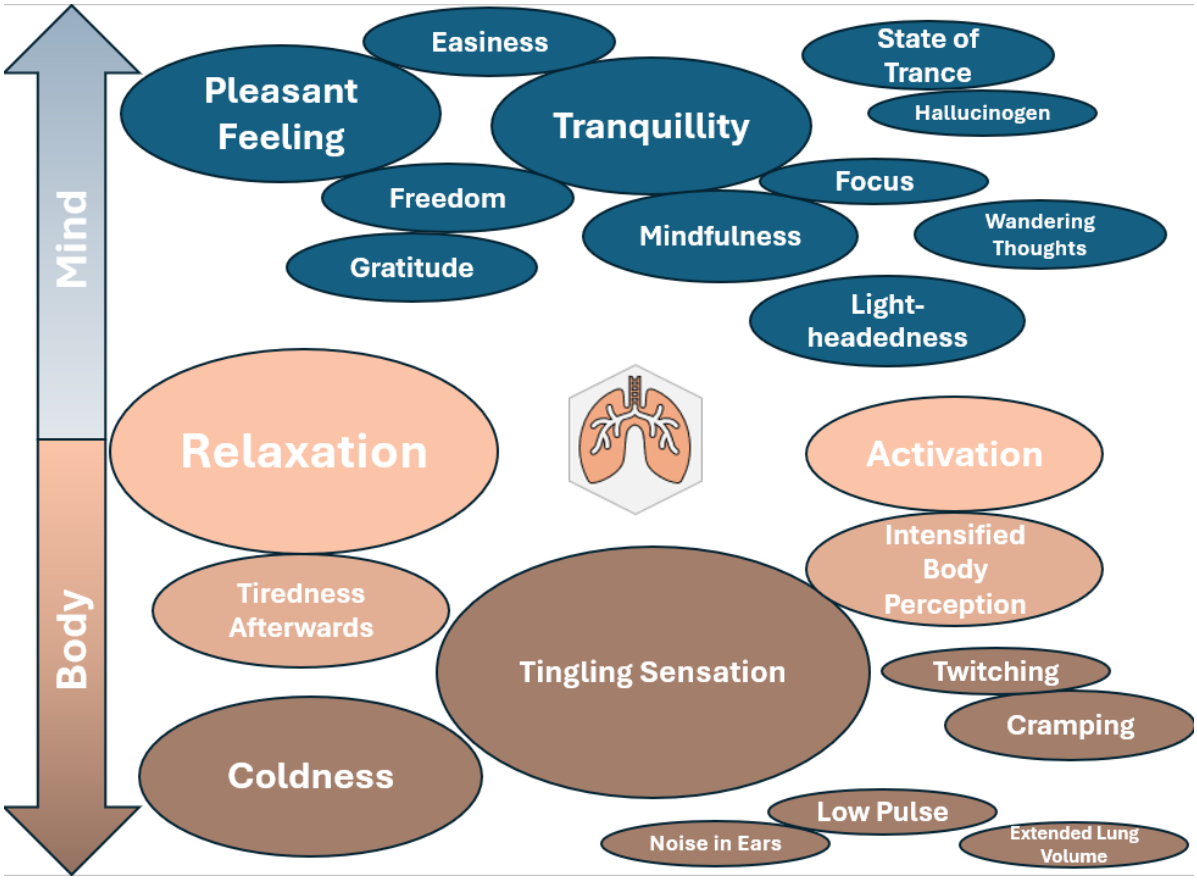
### *Participants' Subjective Experiences*

When going through the subjective experience described by the participants a somewhat blurry distinction between more mental experiences (cognitions and

emotions) and more bodily experiences emerged. See Figure 6 and 7 for a full visual presentation or Table D2 in Appendix D for all indications mentioned.

**Figure 6**

*Participants' Subjective Experiences of Breathwork Exercise*



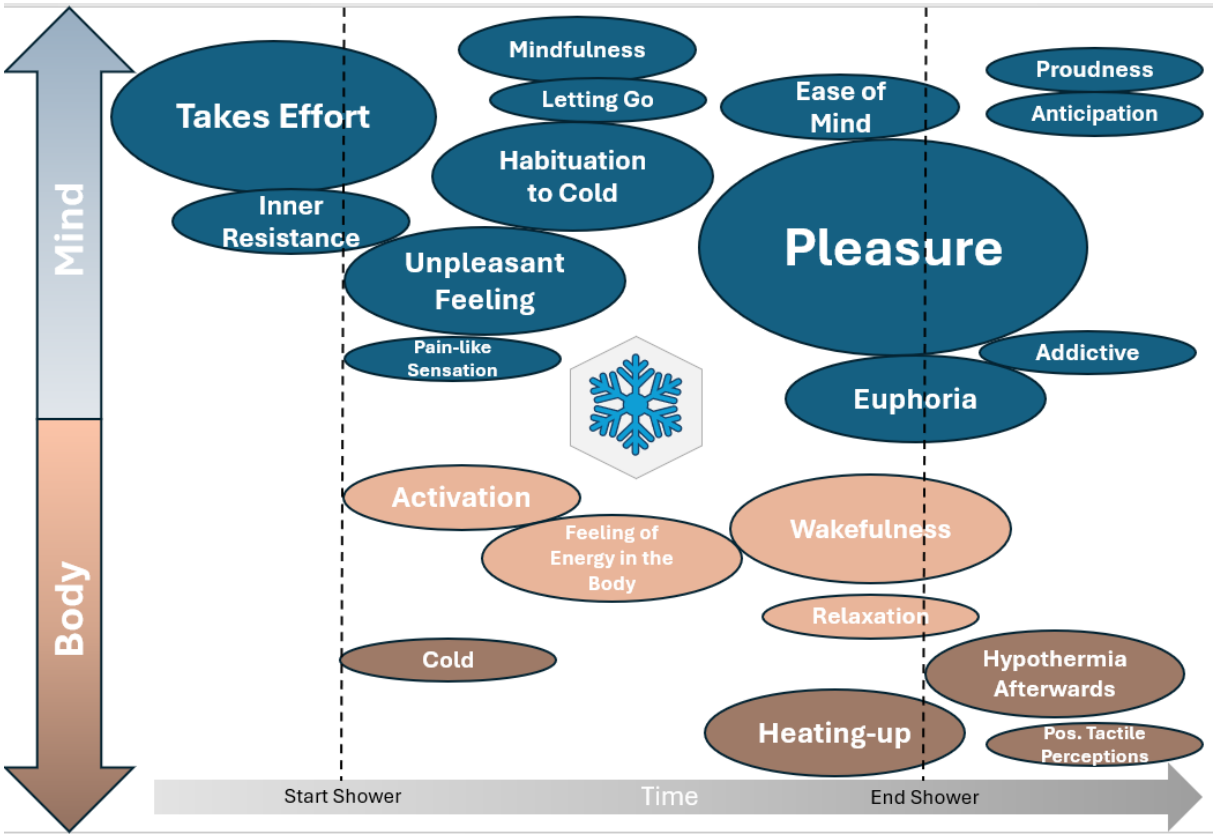

*Note.* Bigger ovals indicate more indications. The vague arrangement of indications in more mental (blueish) or more bodily (brownish) experiences is additionally displayed by different shades of colour accounting for the blurry distinction of mind and body. Indications that share similar meanings were grouped together.

Looking at mental experiences in relation to the breathing exercise the most frequent indications were "pleasant feeling" (5x) and "tranquillity" (5x) mostly relating explicitly to the breath hold or the time shortly after the exercise.

In relation to more bodily experiences indications included a "tingling sensation" (10x), "relaxation" (8x), "coldness" (6x) or an "intensified body perception" (4x). Highly physiological experiences described included "cramping or twitching during breath hold" (3x), and "noise in the ears" (1x).

**Figure 7**

*Participants' Subjective Experiences of Cold Shower Exercise*




*Note.* Bigger ovals represent more indications. The vague arrangement of indications in more mental (blueish) or more bodily (brownish) experiences is additionally displayed by different shades of colour accounting for the blurry distinction of mind and body. Indications that share similar meanings were grouped together and an approximate time dimension (before the exercise to the time after the exercise) was added.

Looking at mental experiences in relation to the cold shower exercise a temporal pattern emerged with participants indicating that it takes "effort" (6x) to start because of "inner resistance" (2x). During the shower the cold was experienced as "unpleasant" (4x). While showering there seemed to be a "habituation or acceptance to the cold" (4x) occurring with the qualities of "mindfulness" (2x) supporting this transition. The feeling tone subsequently shifted into "pleasure" (9x) or "euphoria" (3x) extending into the time after the exercise. After the intervention participants indicated an "addiction potential" (1x) and "anticipatory excitement" (1x) to the next cold shower.

In relation to more bodily experiences the cold shower is described as “activating” (2x) with an “intense body perception”. Some participants indicated that the “body heats up” (3x) and some described that they stayed hypothermic (3x) after the exercise. There were indications about “being awake” (4x) after the shower with “pleasant tactile perceptions” (1x) and “relaxation” (1x).

## Discussion

This feasibility study examined the effects of self-administered breathwork, cold water exposure (CWE), and mindfulness on positive affect (PA), negative affect (NA), depressive symptoms, and anxiety in a naturalistic home setting using a mixed-methods approach including qualitative data on subjective experiences. Large-scale studies investigating the effects of high ventilation breathwork with retention (HVBR) and CWE with mindfulness are still limited. Some recent studies found no evidence for long-term effects of the intervention on psychological and physiological outcomes compared to a passive control group (Ketelhut et al., 2023) and some did find it could reduce depressive symptoms, anxiety, perceived stress (Blades et al., 2024), and improve self-reported energy, mental clarity, and the ability to handle stress (Fox et al., 2025) to a greater or at least comparable degree as slow deep breathing or meditation. This study did not try to find conclusive statistical evidence on the effectiveness of these interventions, but the aim was rather to identify areas for refinement in preparation for the planned study by Haas (2024) specifically and more broadly to offer comprehensive insights into the intervention to hopefully inform future research in the field.

### Quantitative Results

The quantitative results demonstrated consistent and statistically significant acute effects of the interventions on affect. NA was significantly reduced from pre- to post-intervention in all four weeks, with effect sizes ranging from small to large ($g$ = −0.32 to −0.92). PA increased significantly in all four weeks, with large effect sizes ($g$ = 1.02 to 2.04) with the largest effect sizes observed in combined practice weeks 3 and 4. In comparison, Ketelhut et al. (2023) found no significant changes in NA and PA after 15 days of participants performing the WHM which could be because PANAS measures momentary affective states, and the study only included two measurement points (baseline and follow-up), which may not have been sensitive enough to detect more acute or transient effects of the intervention. One participant in this study also mentioned that the effects of the exercises were more temporary.

That said, PANAS is highly correlated with measures of depression and anxiety (Crawford & Henry, 2004) and it is not clear why the acute significant effects of these interventions on NA and PA apparently do not translate to long-term changes of those measures. Studies with larger sample sizes are needed to understand this relationship.

Even though descriptively there were larger effects in week 3 and 4 on affect than week 1 and 2, the repeated measures ANOVA tests across the four weeks did not reveal statistically significant differences in the magnitude of change over time for either NA or PA, suggesting that the acute affective benefits were relatively stable rather than cumulative across the intervention period. This could be due to the relative low number of sessions per week in this study. In contrast, Fox et al. (2025) found that the impact of daily WHM practice on measures of self-reported energy, mental clarity, self-reported state stress, and ability to handle stress increased over the intervention period of 29 days. To understand what practice frequency would be needed for such cumulative benefits to arise, further research is needed.

When comparing the two individual interventions in week 1 and 2, both breathwork and cold shower produced significant reductions in NA with no significant difference between them. In contrast, the cold shower produced a significantly greater increase in PA compared to breathwork ($g$ = −1.21). This was also represented in the subjective experiences with participants describing the breathwork as relaxing, activating, pleasant and tranquil, and the cold shower as pleasurable, euphoric and addictive with far less indications of relaxation. This may point to a key difference in the mechanism of action between the two interventions with breathwork producing more of a calm and activated state and CWE producing more positive emotions by engaging additional reward pathways. This may reflect the neurochemical response to CWE, specifically the documented increases in dopamine and beta-endorphins (Suzuki et al., 2007; Šrámek et al., 2000) which are linked to improved mood (Jain et al., 2019; Radwan et al, 2019).

PHQ-9 and GAD-7 scores on depression and anxiety showed descriptive reductions from baseline to Week 3 and Week 5, but these changes did not reach statistical significance. Those findings may reflect a floor effect. The sample consisted predominantly of healthy participants and the mean baseline scores for both the PHQ-9 ($M$ = 5.91) and GAD-7 ($M$ = 5.63) were relatively low with scores of 5–9 on both scales classified as "mild" (Kroenke, 2001; Spitzer, 2006). With limited

room for improvement and this small sample size, detecting statistically significant changes in depression and anxiety was inherently difficult.

**Qualitative Results**

When looking at general compliance, 15 participants (100%) started the intervention protocol, 12 participants (80%) completed at least one practice day in each of the four weeks, and 10 participants (66.7%) also filled out the qualitative questionnaire in week 4. The reason for participants discontinuing the study is unknown.

All participants seemed to be able to follow the instructions. There were a couple of deviations about doing the intervention less than prescribed, mostly due to a lack of time or sickness. Concerning deviations from the cold shower there were a couple, including shorter pauses, instant whole-body immersions, and even taking ice baths instead of a cold shower. For the breathing intervention there were minor deviations, all of which were not deemed of significance. It must be mentioned though that in the combined practice weeks some participants supposedly only did one practice without the other which could have underestimated the outcome slightly. In a self-administered intervention like this, some deviations must be expected, and researchers of large-scale studies should anticipate those with questionnaires checking for compliance.

Regarding the barriers or problems participants faced during the interventions, there were only some minor difficulties during the breathwork. However, participants often reported of the effort required to start the cold shower, and the unpleasantness experienced during the first minutes of the CWE. This could pose a major hindrance in implementing the practice in the general population or in a population with mental disorders. Even though Fox et al. (2025) reported a higher compliance for the 29-day WHM-remote group ($M$ = 66.9%) compared to the meditation control group ($M$ = 59.8%) in healthy adults, compliance overall was still relatively moderate. In the study by Blades et al. (2024), of the 84 depressed women six (7%) dropped out, all of which were in the WHM group and 10% of the 78 participants completed less than 70% of it. In this study, mean compliance was just 83.3% for participants doing the minimum prescribed intervention times (1-2) per week. Future studies should think about prescribing less interventions per week (e.g., 3–4 days per week) to lower the entry threshold and maximize compliance.

Participants reported some adverse experiences, most of them were normal responses associated with respiratory alkalosis, hyperventilation, and apnea (Foster & Sheel, 2005; Posse et al., 1997; Rapee et al., 1992). One participant reported anxiety with a rapid heartbeat in the evening after doing a scuba dive and later the breathing exercise. It is unclear if the combination of both lead to the anxiety response since pranayama and breath control exercises are part of the preparation for scuba diving (Dressel Divers, 2025). Exploring the relationship between HVBR and diving would go beyond the scope of this discussion, but we recommend including a safety disclaimer about it in future studies. Some participants also reported prolonged hypothermia after the cold shower, whereas others reported increased body heat afterwards. Future studies could investigate the reasons why different participants respond differently to the CWE on a physiological level and if the response would change with subsequent encounters.

Most participants (66.7%) reported positively when asked about differences they experienced when the breathwork was combined with the cold shower. This could be due to the increased ability to concentrate on deep breathing as indicated by some participants when asked about strategies they used for the cold shower. On the other hand, only 20.0% of participants that submitted a questionnaire answered explicitly positive when asked if the mindfulness component made a difference. This could be due to the highly experienced sample with most of them having prior breathwork and cold exposure experience. It seems likely that a mindful attitude was already incorporated in the practices since the participants already learned it in prior encounters with similar interventions. Two participants explicitly stated they already practiced mindfulness in the weeks before. It could also be that the interventions inherently produce a mindful state by reducing NA and enhancing PA which are both associated with increased mindfulness (Waters et al., 2009). This idea is further supported by participants experiences that have similarities to the five-facet mindfulness model (Baer et al., 2006) including reports about, focus (observing), intensified body perception (observing), freedom (non-reactivity), letting go (non-reactivity), and ease of mind (non-reactivity). For both possibilities, the explicit mindfulness instruction is expected to not make a significant contribution. More research is needed to investigate the inherent quality of the interventions to increase mindfulness (with PA and NA as potential mediators).

When asked about the timing for conducting the interventions, only 33.3% of participants reported doing it in the morning. The median time for starting the interventions was between 1pm and 2pm (see Appendix E for full histogram of starting times). This leads to the conclusion that a more variable timeframe for starting the exercises would be advisable to maximize compliance.

The qualitative data on subjective experiences complemented the quantitative data by revealing experiential dimensions of the interventions that fall outside the scope of the selected PANAS items. Participants reported that the breathwork elicited tranquillity, pleasant feelings, tingling sensations, and relaxation, while the cold shower produced a characteristic temporal trend from initial effort and inner resistance, through habituation and acceptance, to post-intervention pleasure and euphoria. For both, the breathing exercise and the cold shower, a blurry distinction between physical and mental/affective experiences emerged. For example, relaxation, wakefulness, and activation could all relate to the workings of the autonomic nervous system, but they could also include and point to an affective state. For most of the other indications the distinction was clearer.

**Limitations**

Several limitations of this study must be acknowledged. First, the most significant is the small sample size ($N$ = 15, with decreasing numbers over the four weeks), which constrains statistical power and the ability to detect small to moderate effects. Second, the lack of a control group means that changes in measurement cannot be causally attributed to the interventions. This is noteworthy concerning the pre–post design for PANAS measurements, which could be susceptible to response bias, as participants may have been motivated to report improvement. Further, the intervention type changed each week, which means that the effects of the different interventions and their combinations are partially confounded with time.

Third, the sample was not representative of the general population. Participants were predominantly male, young, highly educated, and the vast majority had prior experience with both breathwork and cold exposure, with 60% practicing cold exposure several times a week. This introduces a strong self-selection bias and limits the generalizability of the findings to populations without prior experience, to clinical populations, or to more diverse demographic groups.

Fourth, the quantitative measures had notable limitations. Only two PA items (excited and alert) were selected from the PANAS to reduce burden, but this limits

the construct validity of the PA scale and its ability to capture the full range of positive affective states. Furthermore, water temperature was not objectively measured, which introduces variability that could not be controlled for. Participants who were on holiday reported warmer water temperatures than during the winter months in Vienna, where most of the participants conducted the study. There were also some deviations from the study protocol reported, which limits the comparability of the outcomes.

Finally, the qualitative data are subject to the limitations inherent in self-report. As noted, the volume of qualitative feedback varied considerably between participants, meaning that more frequent indications of a particular experience do not necessarily reflect a higher prevalence among participants which limits its interpretability.

**Conclusion**

This mixed-methods feasibility study provides preliminary evidence that self-administered breathwork and CWE, delivered via video instructions in a naturalistic home setting, produce consistent and significant acute improvements in both negative and positive affect across a 4-week intervention period. While both interventions were equally effective in reducing negative affect, cold water exposure generated significantly greater increases in positive affect, a finding supported by qualitative reports associated with the cold shower experience. The finding that most participants did not perceive a meaningful difference with the explicit mindfulness instruction suggests that these interventions may inherently cultivate mindful states, a possibility that warrants further investigation. From a feasibility perspective, the study demonstrated generally high comprehensibility of instructions, compliance, and a manageable adverse effect profile, while also identifying areas for refinement. Given the promising but preliminary results and the limitations discussed, a larger-scale RCT with more diverse and clinically relevant samples, comprehensive measures, and longer follow-up periods is necessary to establish the effectiveness and mechanisms of these practices as accessible mental health interventions.

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## List of Figures

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## List of Abbreviations

| | |
|---|---|
| CWE | Cold water exposure |
| GAD-7 | Generalized Anxiety Disorder Scale-7 |
| HPA | Hypothalamic-pituitary-adrenal |
| HRV | Heart-rate-variability |
| HVB | High ventilation breathwork |
| HVBR | High ventilation breathwork with retention |
| NA | Negative Affect |
| PA | Positive Affect |
| PANAS | Positive and Negative Affect Schedule |
| PHQ-9 | Patient Health Questionnaire-9 |
| PTSD | Posttraumatic stress disorder |
| RCT | Randomized controlled trial |
| WHM | Wim Hof Method |

## Appendix A

## Exclusion Criteria: List of Contraindications

Participation in this study is explicitly not recommended for people with heart disease, cardiovascular disease, cardiac arrhythmias, angina pectoris, Raynaud's phenomenon, cold urticaria, fibromyalgia, hyperthyroidism, multiple sclerosis, frostbite injuries, anorexia, cachexia, acute or chronic kidney failure, high blood pressure, migraine, epilepsy, or (current) diagnosed mental disorders, as symptoms may worsen.

## Appendix B

### Characteristics of Participants (*N* = 15)

| | Mean ± *SD* | % (*N*) |
|---|---|---|
| **Socio-demographic** | | |
| Age (years) | 30 ± 7.1 | |
| Sex (female) | | 26.7 (4) |
| Formal Education | | |
| Completed apprenticeship | | 13.3 (2) |
| High school diploma / university entrance qualification | | 20.0 (3) |
| University/College degree | | 60.0 (9) |
| Other: Technical College | | 6.7 (1) |
| **Prior Breathwork Experience** | | |
| No experience | | 13.3 (2) |
| Wim Hof Method | | 73.3 (11) |
| Holotropic Breathwork | | 46.7 (7) |
| Pranayama | | 60.0 (9) |
| Sudarshan Kriya Yoga | | 20.0 (3) |
| Other: Quantum Light Breath | | 6.7 (1) |
| **Amount of Breathwork Practice** | | |
| tried it occasionally | | 20.0 (3) |
| couple of times a year | | 40.0 (6) |
| several times a week | | 26.7 (4) |
| **Prior Cold Experience** | | |
| No experience | | 13.3 (2) |
| Cold shower | | 80.0 (12) |
| Ice bath | | 53.3 (8) |
| Cold chamber | | 6.7 (1) |
| **Amount of Cold Exposure** | | |
| tried it occasionally | | 6.7 (1) |
| couple of times a year | | 20.0 (3) |
| several times a week | | 60.0 (9) |

## Appendix C

## Quantitative Results

**Table C1**

*Pre- and Post-Intervention Scores for Negative Affect and Positive Affect*

| Outcome | *N* | Pre Intervention | | Post Intervention | | *p* | Hedges *g* [95% CI] |
|---|---|---|---|---|---|---|---|
| | | *M* | *SD* | *M* | *SD* | | |
| **Negative Affect** | | | | | | | |
| Week 1 | 15 | 1.35 | 0.28 | 1.13[a] | 0.20 | < .001 | -0.81 [-1.24, -0.38] |
| (2. Session) | 11 | 1.35 | 0.44 | 1.09 | 0.19 | | |
| Week 2 | 13 | 1.49 | 0.56 | 1.26 | 0.34 | .015 | -0.32 [-0.56, -0.08] |
| (2. Session) | 12 | 1.58 | 0.44 | 1.20 | 0.31 | | |
| Week 3 | 12 | 1.50 | 0.44 | 1.17 | 0.17 | .027 | -0.92 [-1.81, -0.03] |
| (2. Session) | 4 | 1.25 | 0.25 | 1.10 | 0.12 | | |
| Week 4 | 12 | 1.62[a] | 0.58 | 1.18 | 0.26 | .004 | -0.70 [-1.16, -0.25] |
| (2. Session) | 3 | 1.73 | 1.27 | 1.33 | 0.58 | | |
| **Positive Affect** | | | | | | | |
| Week 1 | 15 | 2.67 | 0.82 | 3.67 | 0.67 | .002 | 1.26 [0.34, 2.19] |
| 2. Session | 11 | 3.09 | 0.97 | 3.77 | 1.03 | | |
| Week 2 | 13 | 3.12 | 0.89 | 4.04 | 0.78 | < .001 | 1.02 [0.50, 1.55] |
| 2. Session | 12 | 2.50 | 0.77 | 3.63 | 0.71 | | |
| Week 3 | 12 | 2.67 | 0.62 | 3.92 | 0.51 | < .001 | 2.04 [1.04, 3.03] |
| 2. Session | 4 | 3.25 | 1.19 | 4.50 | 0.41 | | |
| Week 4 | 12 | 2.67 | 0.81 | 3.92 | 0.79 | < .001 | 1.45 [0.76, 2.14] |
| 2. Session | 3 | 3.50 | 1.32 | 4.00 | 1.00 | | |

*Note*. *M* = mean; *SD* = standard deviation; *p*-values are from paired *t*-tests; hedges' *g* effect sizes are reported with 95% confidence intervals (CI). Statistical analysis was only done on the first session of each week; 2. session of a week is just reported descriptively.

[a] Value winsorized at the 5th and 95th percentiles.

**Table C2**

*Pre- and Post-Intervention Scores for NA and PA for Cold versus Breathwork*

| Outcome | *N* | Pre Intervention | | Post Intervention | | *p* | *g* [95% CI] |
|---|---|---|---|---|---|---|---|
| | | *M* | *SD* | *M* | *SD* | | |
| **Negative Affect** | | | | | | | |
| Breathwork | 14 | 1.30 | 0.46 | 1.13 | 0.28 | .002 | -0.28 [-0.49, -0.07] |
| Cold Shower | 14 | 1.53 | 0.38 | 1.30[a] | 0.40 | < .001 | -0.73 [-1.12, -0.34] |
| **Positive Affect** | | | | | | | |
| Breathwork | 14 | 3.04 | 0.80 | 3.54 | 0.75 | .038 | 0.61 [0.02, 1.20] |
| Cold Shower | 14 | 2.71 | 0.94 | 4.14 | 0.60 | < .001 | 1.56 [0.96, 2.16] |

*Note***.** Intervention scores taken during week 1 and 2. *M* = mean; *SD* = standard deviation; *p*-values are from paired *t*-tests; *g* = Hedges' *g* effect sizes reported with 95% confidence intervals (CI).

[a] Value winsorized at the 5th and 95th percentiles.

## Appendix D

## Qualitative Results

**Table D1**

*All Indications of Directed Content Analysis*

| Question | Indications (times mentioned) |
|---|---|
| (a) Instruction comprehension | background music a bit too loud in the videos (1x) |
| (b) Deviations: less sessions | no time (4x)<br>sickness (3x)<br>difficulty integrating it into the daily schedule (2x)<br>inability to overcome inner resistance<br>bad time management<br>combination of Breathwork/cold shower was too much |
| (b) Deviations: more sessions | curiosity<br>consistency with the week before |
| (b) Deviations: Cold Shower | shorter/improvised pauses (3x)<br>showering the whole body from the beginning on" (2x)<br>taking an ice bath instead of a shower (2x)<br>taking a warm shower after the cold |
| (b) Deviations: Breathwork | lying down (4x) (on a shaki mat)<br>breathing exercise without the cold shower (2x)<br>cold shower without the breathing exercise in the combined weeks<br>breathing out trough constricted lips after recovery breath<br>watching a Wim Hof instruction video on YouTube instead of the study video |
| (c) Barriers or problems: Breathwork | difficulty concentrating (3x)<br>difficulty holding the breath (2x)<br>difficulty maintaining the breathing rhythm |
| (c) Barriers or problems: Cold Shower | takes effort (6x)<br>unpleasantness during the shower (5x)<br>resistance before shower (2x)<br>difficulty translating the interventions into a long-term routine (2x)<br>little time in the morning to do such exercises<br>video instruction is distracting |
| (d) Adverse experiences or negative side effects | prolonged hypothermia after cold shower (3x)<br>noise/tinnitus after breathing exercise (2x)<br>existing tinnitus got temporarily worse and settled down again<br>Anxiety with a rapid heartbeat before going to bed (after a scuba dive on the same day)<br>dizziness after breathing exercise |

| Question | Indications (times mentioned) |
|---|---|
| | cramping of the body during breathing |
| (e) Difference in the cold shower in week 3 | less cold (2x)<br>calmer (2x)<br>more pleasant<br>less resistance<br>heat body<br>better tolerating the cold<br>more difficult to start<br>no |
| (f) Difference with mindfulness in week 4 | no difference (4x)<br>already practiced mindfulness in the weeks before (2x)<br>better mindset<br>feeling of powerfulness<br>less resistance<br>hold the breath longer<br>enjoy it more<br>elevated the spirit to other planes |
| (g) Specific Strategies | deep breathing (2x)<br>concentrating on the breath during the shower<br>not thinking much before taking the shower (2x) just doing it |
| (h) Timing | after getting up (10x)<br>when I have the time (4x)<br>after doing sports (3x)<br>between two meetings (3x)<br>when tired<br>after a stressful event<br>before going to bed |
| (i) Other comments | holiday with water temperature not that cold (3x)<br>increase in alertness afterwards, but fatigue a couple of hours later<br>effects of the exercises were more temporary |

*Note.* Indications with number of times mentioned in brackets. No number means it was indicated one (1x) time.

**Table D2**

*All Indications of Subjective Experiences*

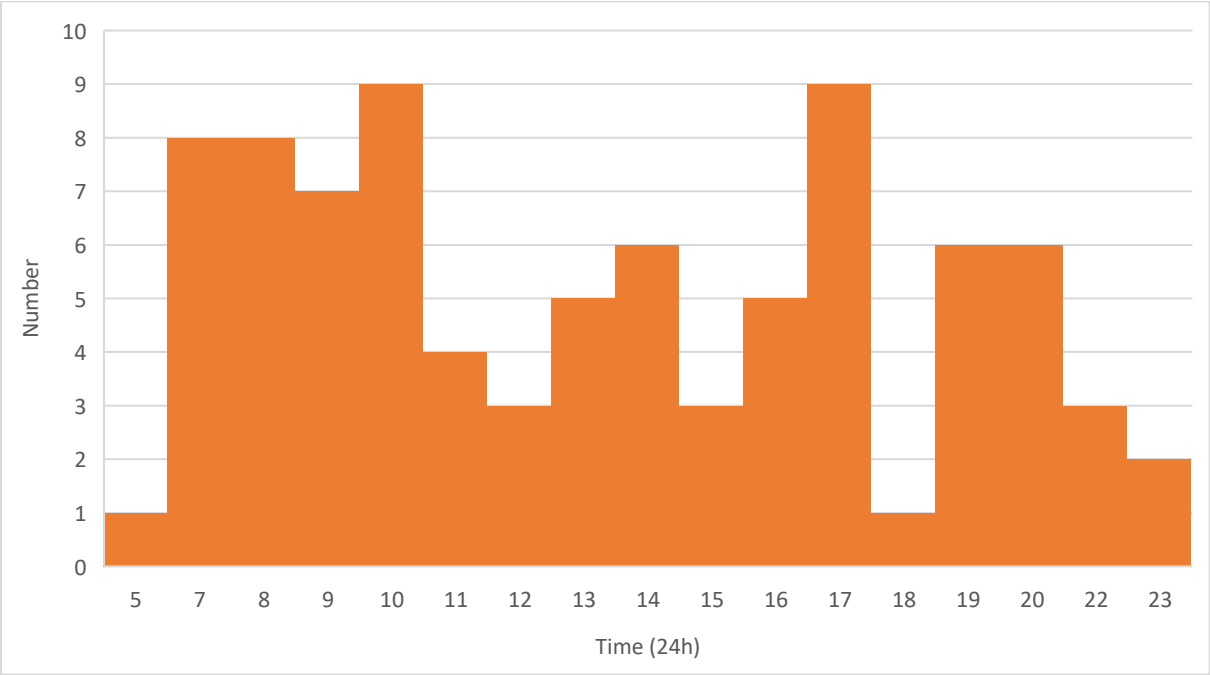
| Domain | Indications (times mentioned) |
|---|---|
| **Breathwork** | |
| Mental Experiences | pleasant feeling (5x)<br>tranquillity (5x)<br>light-headedness (3x)<br>mindfulness (3x)<br>state of trance (2x)<br>gratitude (2x)<br>freedom (2x)<br>easiness (2x)<br>focus (1x)<br>hallucinogen (1x)<br>wandering thoughts (2x) |
| Bodily Experiences | tingling sensation (10x)<br>relaxation (8x)<br>coldness sensation (6x)<br>intensified body perception (4x)<br>activation (4x)<br>tiredness afterwards (4x)<br>sensation of energy or vibration (4x)<br>cramping during breath hold (2x)<br>twitching during breath hold (1x)<br>low pulse (1x)<br>noise in the ears (1x)<br>extended lung volume (1x) |
| **Cold Shower** | |
| Mental Experiences | effort (6x)<br>inner resistance (2x)<br>unpleasant (4x)<br>pain-like sensation (1x)<br>habituation or acceptance to the cold (4x)<br>mindfulness (2x)<br>letting go (1x)<br>pleasure (9x)<br>ease of mind (2x)<br>euphoria (3x)<br>proud (1x)<br>addiction potential (1x)<br>anticipatory excitement (1x) |
| Bodily Experiences | cold (1x)<br>activating (2x)<br>intense body perception (1x)<br>energy (2x)<br>body heats up (3x) |

| Domain | Indications (times mentioned) |
|---|---|
| | stayed hypothermic (3x)<br>being awake (4x)<br>pleasant tactile perceptions (1x)<br>relaxation (1x) |
| **Other experiences** | euphoria (3x)<br>wakefulness (3x)<br>focus (2x)<br>activation (2x)<br>pleasant feeling (1x)<br>powerfulness (1x) |

*Note.* Indications with number of times mentioned in brackets.

## Appendix E

## Participants' Starting Times for Intervention




*Note.* Time was registered in Central European Standard Time (CEST), it was not accounted for participants performing the interventions in different time zones.