Graduate thesis

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How Do Research Paradigms Shape Our Knowledge Of Breathing Techniques? A Systematic Review

Graduate thesis in Clinical Programme for Psychology
Supervisor: Truls Ryum
Co-supervisor: Lea Loncar og Elena Ian
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To my family -
both given and chosen.

Abstract

Objective: Much evidence implies breathing techniques to have positive health effects. However, our current understanding of these practises is somewhat fragmented, as different breathing techniques are approached by various theories and research paradigms. In this review, studies originating from two different approaches will be compared. Research on slow breathing techniques (SBT) will represent the positivistic paradigm, while "Holotropic Breathwork" (HB) will typify the phenomenological paradigm. The aim is to examine how the unalike approaches influence our knowledge of these practises.

Method: Systematic searches of PubMed and PsychINFO, using search words related to cardiorespiratory outcomes, central nervous system outcomes and psychological outcomes, were conducted for SBT and for HB. The present review followed the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) Guidelines.

Results: From a pool of 839 abstracts, 15 papers (SBT: 9, HB: 6) met the inclusion criteria. The two research bases differed in quantity, methodological quality and in what outcomes were measured. SBT papers had extensive assessments of cardiorespiratory and cortical outcomes. These studies focused less on psychological outcomes, and mainly assessed relaxation, negative and positive emotions. Conversely, HB papers measured phenomenological experiences to a large extend. Alterations of consciousness, perception and emotions were measured, as well as long-term outcomes of change in personality, purpose in life and spirituality. None of the HB papers measured biological outcomes. Methodological quality in SBT papers were superior to HB papers in both quantity and methodological quality.

Conclusion: The findings suggest the research paradigms to generate specific strengths and weaknesses in the knowledgebase on each technique. The main issue was that each approach seemed to favour certain outcomes, while neglecting others. Further, the variance in methodological traditions appears to accumulate reliable evidence on SBT, while results in HB papers are left more disputable. In sum, the difference between research paradigms could retain a fragmented knowledgebase, and valuable data could be overlooked. Future studies on breathing techniques ensure adequate methodological quality regardless of paradigmatic origin and adopt a more integrative approach when assessing outcomes.

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“Whether one focuses on objective reality at the expense of subjective experiences, or privileges psychological reality at the expense of physical foundation – both approaches ignore systemic connections at different levels of complexity (Mark-Tarlow et al, 2020)”

Introduction

Breath is crucial for human existence. It withholds a remarkable quality, as the only vital, autonomic mechanism that can be controlled voluntarily (Jerath & Beveridge, 2020). There is a close, bidirectional relationship between the respiratory- and central nervous system (Jerat & Crawford, 2015; Laborde et al., 2022). Therefore, breathing techniques are potential tools for self-regulating internal states. Recently, there have been a growing interest in how breathing techniques modulate emotions, cognition, and physiological outcomes (Zaccaro et al., 2021; Hopper et al., 2019; Jayawardena et al., 2020), both in society and in research. Accordingly, different techniques are found associated with various beneficial outcomes, such as reduced stress, anxiety, and depression (Zaccaro et al., 2019), increased mindfulness, spirituality and meaning (Puente 2014a, b, Uthaug et al., 2022), as well as lower blood pressure and increased heart rate variability (Laborde et al., 2022; Li et al., 2015; Chen et al., 2017).

These findings imply breathing techniques to be relevant for mental health. This is especially important considering the worldwide escalation of stress and mental illness (WHO, 2022). As we are facing increasing strains from environmental and economic challenges, breathing techniques could be highly accessible and inexpensive ways for preserving mental health. The need of new methods in clinical settings is also relevant, as there are patients who do not benefit from conventional talk-therapy and medication. (Dragioti et al., 2017; Kverno & Mangano, 2021; Cirpiani e tal., 2018).

However, the current utilization of breathing techniques is rather limited, especially in clinical settings. Could this be related to challenges in the knowledgebase on these interventions? One issue seems to be evident in this scientific field: a certain division between research paradigms. Specifically, the “western” approach to breathing techniques tends to be oriented towards a positivistic, biomedical research paradigm (Zaccaro et al., 2019; Russel et al., 2018; Russo et al., 2017), while the “eastern” approach aligns with the phenomenological paradigm and transpersonal psychology (Puente, 2014a, b; Miller & Nielsen, 2015; Grof & Grof, 2010; Grof, 1985). In addition, each approach focuses on different techniques. Therefore, it appears to be an epistemological polarization in how breathing techniques are understood and examined. This leads to the research question of this review: How do these different paradigms shape our current knowledgebase of breathing techniques? To investigate this question, the present review will compare studies on two breathing techniques from two

different paradigms. Studies on slow breathing techniques will represent the biomedical, positivistic approach, while studies on "Holotropic Breathwork" (Grof & Grof, 2010) will typify the phenomenological, transpersonal approach. The aim is to explore how different paradigms shape our understanding of each technique, and what strengths and weaknesses might be generated within each research base. Based on the findings, the review will address implications to improve future studies and to expand our overall knowledge of these breathing practises.

The current review focuses on non-clinical populations, which limits any conclusions on clinical utilization. However, the state of knowledge generated by non-clinical studies can inform utilization and influence the relevance of clinical studies. This makes it valuable to first establish trends in studies on general populations.

Slow breathing techniques

Slow breathing techniques (SBT) is a collective term. In general, it refers to all breathing techniques where the pace of respiration is decreased and the frequency of breaths per minute is lower than one's regular rate. The lowered frequency is often accompanied by deeper breaths, as the slowing of pace causes expansion of the lungs into the diaphragm (Hopper et al., 2020). This differs from ordinary breathing, which often involves only using the abdomen or ribcage during exhalation and inhalation, resulting in more shallow breaths (Fogarty et al., 2018).

SBT are utilized in various context, and specific performance will vary between setting. In clinical contexts, SBT is often used within the framework of mindfulness-based cognitive therapy (Wells, 2009), and acceptance and commitment therapy (LaRowe et al., 2022; Harris, 2019). In these settings, the therapist will count to certain numbers during each inhalation and exhalation to help the patient slow their breathing rate. The exercise is often given as a tool to reduce anxiety and increase relaxation (Harris, 2019). Another clinical utilization of SBT is biofeedback training (Alneyadi et al., 2021). During biofeedback, the frequency of breath is guided by real-time feedback of the patients' physiological responses, measured by sensors attached to the body. The physiological responses are translated into auditory or visual stimuli that guides the person to breath in an optimal range. This optimal rate is also called resonance frequency, refering to the frequency that provides the highest extend of synchronization between cardiorespiratory outcomes for the specific induvial.

The predominant utilization of SBT occurs within research environments. In research on SBT, the rate of breath is often specified to insure comparable findings. Most articles uses breathing rate under 10 breaths per minute (Zaccaro et al., 2019), as the majority of beneficial findings are associated with such frequencies (Vaschillo et al., 2002, Vaschillo et al., 2006). The pace is either guided by a visual, auditory, or kinaesthetic stimulus following a certain frequency (referred to as paced breathing) or by biofeedback training. Before, during and after the intervention, psychological and physiological outcomes are monitored, so that the effect of slow breathing can be compared to normal breathing. This has yielded an extensive body of research demonstrating favourable outcomes of SBT. Much evidence shows beneficial outcomes in the cardiovascular-, cardiorespiratory and central nervous system. Examples are increased heart rate variability (Radaelli et al., 2004; Guzik et al., 2007), decreased blood pressure (Joseph et al., 2005) increased vagal tone (Chang et al., 2013) and increased parasympathetic activity in the autonomic nervous system (Pal et al., 2004; Limberg et al., 2013). Psychologically, the primary findings involve increased relaxation and calmness, as well as decreased feelings of stress and anxiety (Zaccaro et al., 2019).

Holotropic Breathwork

Holotropic Breathwork (HB; Grof, 1985; Grof & Grof, 2010) is a breathing technique developed ` by Stanislav and Christina Grof in the 1980. HB was developed as a non-drug alternative for achieving altered states of consciousness, similar to those found during psychedelic experiences (Grof & Grof, 2010). HB is available through workshops and retreat centres. The HB sessions are performed in groups and lasts between 2-3 hours. The session is guided by a facilitator trained in HB, who will start the session by ensuring a safe group environment and inform the participants on how to breath. The group is divided into breathers and “sitters”; the “sitter” will support and assist the breathers if needed during the practise. After the first breathing session, the roles are switched. The breathing involves prolonged, voluntary hyperventilation, accompanied by evocative music. After the breathing sessions, the participants can share their experiences with the group and express themselves through artwork and drawing. The overreaching mechanism of HB is using hyperventilation to initiate a non-ordinary state of consciousness (NSC; Grof & Grof, 2010), and thereby access and process important emotions, memories and/or physical blockages. Grof claims that much of this material is difficult to reach through ordinary states of consciousness, because it is suppressed in everyday life. It can therefore be challenging to access through conventional talk-therapy. Grof argues that if the supressed material is extensive, it can hinder personal

growth and self-actualization, potentially resulting in symptoms of depression, anxiety, and trauma (Grof & Grof, 2010). Processing such material in a safe, supporting environment, sharing the experience with others, and expressing it through art and writing, is thought to help integrate and resolve the emotional and/or physical blockages.

The rationale for HB mirrors some of its theoretical roots. Similar to humanistic psychology, personal growth and self-actualization are important values in this practise. However, the focus on NSC, as well as transcendental and spiritual experiences, implies the central role of transpersonal psychology in HB (Grof & Grof, 2010). According to Friedman & Hartelius (2023), transpersonal psychology aims to honour the entire spectrum of human experiences, including transcendental experiences through altered states of consciousness. To transcend is described by Welsh & Vaughan (1993) as an experience where one's sense of identity extends (transcends) the individual, and where one encompasses a wider aspect of life and cosmos. According to Grof, the non-ordinary state of consciousness (NSC) generated by HB, can enable personal growth, positive therapeutic change and provide valuable spiritual insights (Grof & Grof, 2010).

Rationale for the current review

Evidently, SBT and HB are approached through somewhat different research paradigms and theories. In research on SBT, observable, objective and measurable outcomes seem to receive substantial attention. Though SBT originated from eastern practises (Zaccaro et al., 2019), the modern, scientific approach appears to be more concerned with biological outcomes. This suggests the biomedical, positivistic paradigm to be influential for this research base. On the other hand, research on HB could be argued inherently phenomenological, as qualitative and in-depth subjective descriptions of alterations in consciousness and transcendental experiences are pivotal transpersonal psychology.

It is however important to note that SBT and HB vary in what acute effect they aim to achieve. SBT is associated with increased parasympathetic activation and relaxation, while HB is utilized to activate arousal, emotions, and memories. It is therefore important to clarify that the purpose of this review is not to compare acute effects of these two techniques. The intention is to examine what strengths and weaknesses might evolve within each research base due to their unalike theories and scientific paradigms.

This further raises the question; would paradigmatic differences between research bases even be an issue? Approaching a phenomenon from different epistemological

viewpoints is nothing new, and having multiple perspectives can even broaden the knowledge in fields of research. However, the problem emerges if the different approaches cause certain outcomes to be overlooked, certain techniques to be underexamined or each research base to vary in general quantity or methodological quality. Such aspects could further influence what techniques are acknowledges in which settings. Today, the clinical utilization of breathing techniques primarily involves SBT (Wells, 2009; LaRowe et al., 2022; Harris, 2019). In contrast, there are no guidelines or recommendation for clinical usage for HB in the Norwegian guidelines for psychologist. Could this be related to different strengths and weaknesses in the corresponding research bases? A comparative review is necessary to examine these issues.

One last motive for addressing the effect of different research paradigms, is the unique value of combining the biomedical and phenomenological approach. Integrating these perspectives could enable a rich knowledge base, addressing a spectre of human experiences. This is highly relevant for increasing mental health in both clinical and non-clinical populations. From the biological perspective, there is a growing body of research on how dysregulation in the ANS is associated with stress, depression, anxiety, and trauma (Sgoifo et al., 2015; Won et al., 2016; van der Kooy et al., 2006). Breathing techniques are proven efficient in regulating ANS, providing a potential tool for self-regulating autonomic activity. Phenomenological approaches suggest breathing techniques to be associated with increased mindfulness, self-actualization, spiritual awareness, and processing of challenging emotion (Grof & Grof, 2010; Miller & Nielsen, 2015; Rhinewhine & Williams, 2007). These are all factors associated with increased mental health (Fuijsaki, 2020; Breedvelt et al., 2019; Goldberg et al., 2018; Weber et al., 2014). Combining these perspectives could not only be of great value for the knowledgebase on breath, but for understanding the relationship between phenomenological experiences and biological effects. A review of the current state of research on breathing techniques could be helpful for developing such integrative perspective.

Method

The current systematic review has been conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). PRISMA is a 27-item checklist developed to ensure quality in systematic reviews. The reviewer (VKN) performed the search strategy, the study selection, the data synthesis, and the quality assessment independently. For details on PRISMA guidelines, see **Supplementary Table S3.**

Search strategy

A systematic search of PubMed and PsychINFO was conducted in May 2022. Additional studies were identified between June 2022 and July 2022, through a manual search and correspondence with one researcher. The search strategy used various search words, both for interventions (either slow breathing techniques OR Holotropic Breathwork) and outcomes (both physiological and/or psychological outcomes). Searches were performed using for interventions- and outcomes keywords combined with the Boolean operator "AND" (**Table 2**). A search example for interventions and outcomes combined is: "slow breath" OR "slow breathing" OR "holotropic breathwork" AND "emotion" OR "stress" OR "consciousness" OR "awareness" OR "well-being" OR "heart rate variability" OR "EEG" OR "fMRI" OR "cardiorespiratory coherence". Full list of keywords **(Appendix 1)** is available in Supplementary Material. Both acronyms and the extended names were searched for.

Study Selection

To ensure that the selected studies were of relevance to the research questions, the Population, Intervention, Comparison, Outcomes and Study Design (PICOS; Methley et al., 2014) worksheet was adopted. As seen in **Table 1**, studies that were identified in the literature search were included if:

- The paper is published in peer-reviewed journal
- The sample is healthy humans
- The age range is of 19 and 65
- The subjects were both experienced or novel to the breathing technique
- The intervention either involved slow breathing techniques (interventions of direct breath control that slows the breath to less than 10 breaths per minute) or involved Holotropic Breathwork (in accordance with the technique developed by Stanislav Grof; involving evocative music, prolonged hyperventilation, post-session integrational work)

- Preferably the study involved control group or comparison group, but relevant studies with no comparison group were accepted
- Any physiological or psychological outcome was measured as dependent variable (including variables not explicitly stated in the search)
- The variables were either measured during and/or immediately after and/or as long-term effect

Identified studies were excluded if:

- Any study involving clinical samples
- The subjects were either young (<19 years) or old (> 65 years)
- For slow breath studies: Interventions involving breathing at a higher rate than 10 breaths per minute; breathing modulation as a by-product of other interventions (i.e., Transcendental Meditation, Qigong, Tai Chi); breathing modulation were additional tasks were added (i.e., cognitive tasks, visualization, active awareness of breath; emotions were actively induced in the protocol (i.e., fear, anger, stress).
- For Holotropic Breathwork-studies: Papers on other similar types of exercises (i.e involving rapid breathing) that did not specifically use "Holotropic Breathwork" were excluded
- Studies were not published in a peer-reviewed journal
- Studies were not available in English

Table 1: Population, Intervention, Comparison, Outcomes and Study Design (PICOS)

Parameter	**Inclusion criteria**	**Exclusion criteria**
Population	Peer-reviewed Healthy humans Age between 19 and 65 Experienced or novel to breathing technique	Clinical samples Age < 19 or > 65 years
Intervention	Slow breathing technique (any breathing technique involving slowing of the breath < 10 breaths per minute) OR Holotropic Breathwork[1]	For slow breathing techniques: Techniques involving breathing at a higher frequency than < 10 b/min Techniques involving additional tasks (yoga-poses, stretching, cognitive assignments, visualization) Techniques actively inducing emotions (i.e., anger, stress, fear) For Holotropic Breathwork: Techniques that are altered from the original method (i.e., not involving music, not involving integrative work)
Comparison	Preferably control group (normal breathing), comparison group (different technique, no technique) or no comparison	

Outcomes	Any physiological outcome (i.e., heart rate variability, cardiorespiratory coupling, respiratory sinus arrythmia, EEG, fMRI) and/or psychological outcome (i.e., alterations in emotion, consciousness, awareness, stress, well-being, comfort) Effects during, immediately after and long-term effects were included	
Study design	Quasi-experiment, pre-post, within subjects, randomized controlled	Mere case report

[1]Following the technique developed by Stanislav Grof (2010), described in introduction.

Data extraction

After performing the search and selecting eligible studies based on the inclusion criteria, the data extraction was performed. The extracted data included the study objective and intervention, the study design, the outcome variable(s) assessed, methodological quality and the respective findings.

Data synthesis

Data synthesis was done following data extraction. Identified outcome variables were displayed and categorized into their respective category (cardio-respiratory system, central nervous system or psychological effects). Results where synthesized withing each category to address the specific research questions.

Quality review

The methodological quality was reviewed for each article using a quality assessment tool corresponding to the specific design. For details on each tool, see **Supplementary Table 2 and 3.**

For within subject design, the "Single-Case Reporting Guideline In BEhavioural Interventions (SCRIBE) check-list" was used to assess the general format, methodology, design, participants, context, measurements interventions and analysis (Tate et al., 2017). Total score was 26. As there is no formal consensus on scoring the SCRIBE-checklist, the reviewer chose to categorize scores into low (< 10), medium (10-18), and high (18-26).

For pre-post designs, an assessment tool adapted from various systematic reviews "Quality Assessment Tool for pre-post designs" (Cummings et al., 2008) was used to assess

sampling, design, control of confounders, data collection and outcome measurement, statistical analysis, conclusions, and drop-outs. The adjusted total score was 1.0 (> 0.6 = low, 0.61-0.79 = medium, 0.8-1.0 = high) (Cummings et al., 2008).

Results

Flow Diagram

The flowchart of the study selection process is displayed in Figure 1. The results of systematic search, according to keywords and returned studies, are described in Table 2.

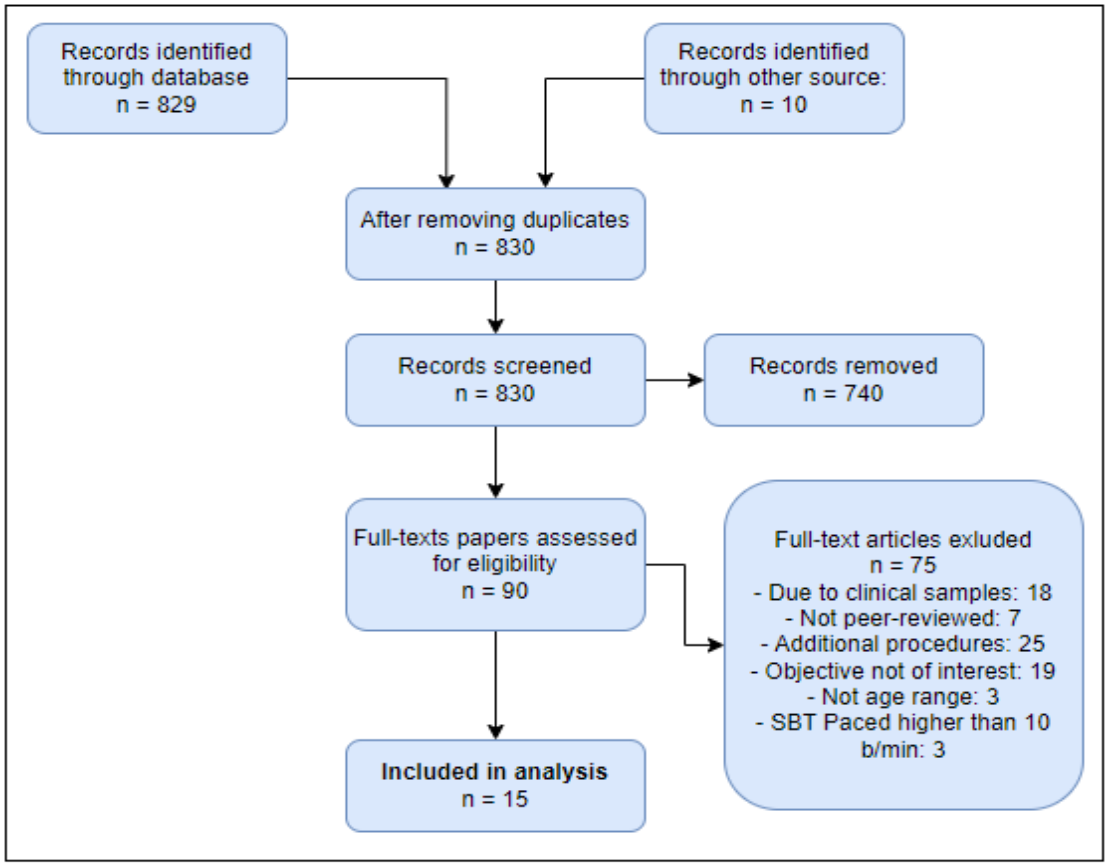

Figure 1: Flow chart of selection process

Table 2: Study search

Database	Date		Keyword	Search in	Studies found
Search for intervention and specified psychophysiological outcomes					
		#1	slow breath OR slow breathing OR deep breath OR deep breathing OR Holotropic Breathwork OR Breathing exercise OR breathing technique	Title/ Abstract	3485

		#2	Cardiorespiratory coherence OR cardiorespiratory synchronization OR heart rate variability OR HRV or respiratory sinus arrythmia OR RSA OR EEG OR electroencephalogram OR emotion OR stress OR well-being OR consciousness OR awareness	Title/ Abstract	1,400,257
		#3	Combine #1 and #2		854
		#4	Limit to (English)		809
		#5	Limit to "Humans, 19+"		**511**
PsychINFO		#1	slow breath OR slow breathing OR deep breath OR deep breathing OR Holotropic Breathwork OR Breathing exercise OR breathing technique	Title/Keywords	734
		#2	Cardiorespiratory coherence OR cardiorespiratory synchronization OR heart rate variability OR HRV or respiratory sinus arrythmia OR RSA OR EEG OR electroencephalogram OR emotion OR stress OR well-being OR consciousness OR awareness	Title/Keywords	699,179
		#3	Combine #1 and #2		351
		#4	Limit to (English)		328
		#5	Limit to "Humans, 19+"		**318**

Study selection

A pool of 829 studies were identified through database search (HB= 2; SBT=827). Ten additional studies on HB were identified through other sources; one collected from direct communication with another researcher and nine from an earlier literature review of HB (Uthaug et al., 2022). Due to either duplication or lack of relevance to the review, 740 papers were removed from the review. After assessing the remaining 90 papers for eligibility criteria (HB=12, SB=77), a final pool of 15 studies met the eligibility criteria and were included in the present work. Of these, six were on HB and nine were on SBT.

Synthesized effects: Research papers on Slow Breathing Techniques

Nine papers on SBT were included in the review. All papers were identified through either PubMed or PsychINFO. The identified outcomes are displayed in Table 3. Three papers assessed only one category of outcomes; five papers assessed two categories of outcomes and one paper assessed all three categories combined. For description of the detected cardiorespiratory, cortical, and psychological terms, see Appendix 2 and 3 in **Supplementary Material.**

Table 3: Outcomes assessed and methodological quality rating for all SBT papers.

Study	Time of assessment	Psychological outcome[a]	Cardiorespiratory system[b]	Central nervous system	Overall quality assessment
Slow breathing techniques					
Zhang et al., 2017	During	-	ECG recording, blood pressure (QRS-complex, pulse transit time analysis, respiratory oscillations, phase coupling, R-R amplitude oscillation, breathing regularity)	-	Medium to high[1]
Dick et al., 2014	During and immediately after	-	ECG, blood pressure (heart and respiratory rates, power spectral density)	-	Medium to high[1]
Fonoberova et al., 2014	During	-	Respiration period, thoracic and abdominal pressures (blood pressure, heart period)	-	Medium[1]
Lehrer et al. 2003	During, across single sessions and long-term	The Relaxation Inventory, Side Effects of Relaxation Scale	ECG, blood pressure, End-tidal CO2, (QRS complexes, HRV indices, Baroreflex gain)	-	High[2]
Lin et al., 2014	During	Relaxation (Visual Analogue Scale; VAS)	ECG (R-R intervals heart rate, HRV indices)	-	High[2]
Sutarto et al., 2012	Long-term	Depression, Anxiety and Stress Scale (DASS)	ECG, respiration belt (HRV, R-R intervalls)	-	High[2]
Hsu et al., 2020	During	-	ECG, respiratory belt (power spectral analysis, QRS complex)	MEG (time frequency representations of respiration locked MEG, unity-based time normalization of respiration-locked MEG)	Medium to high[1]
Xiao Ma et al., 2017	Long-term	Emotion (PANAS), Attention (NCT)	-	Cortisol	Medium[2]
Hinter-berger et al., 2019	During	Relaxation (Naturalness, valence and arousal on 3-point scale)	ECG, Respiration belt (HRV indices, Fourier transform)	EEG (Slow cortical potential)	Medium[1]
Holotropic Breathwork					
Rock et al., 2015	During	Phenomenological subsystems (PCI), Alterations in consciousness (ASA)	-	-	Medium[1]

Denisa, 2003	During, immediately after, and long-term effects	Purpose in Life Questionnaire (PIL), Attitudes and values (Values-Belief Q-Sort), Personal Orientation Inventory (POI) and qualitative interview	-	-	Low[1,2]
Somensula et al., 2017	Immediately after	Stress	-	-	Low[2]
Puente, 2014a	During, long-term effects	Brief Symptom Inventory (BSI), Purpose of life (PIL), Death Anxiety Scale (DAS[a]), Personal orientations Inventory (POI), States of consciousness Questionnaire (SCQ), Brief Persisting Effects Questionnaire (BPEQ)	-	-	Low to medium[1]
Puente, 2014b	During	States of consciousness questionnaire (SCQ)	-	-	Low to medium[1]
Miller & Nielsen, 2015	Long-term effects	Temperament and Character Inventory (TCI), Interpersonal problems (IIP) Symptom Checklist (SCL-90-R)	-	-	Low to medium[1]

Note: a) See Appendix 3 and 4 in **Supplementary Material** for description of each instrument. b) See Appendix 2 in **Supplementary Material** for details on terms. 1) Quality score assessed using "Single-Case Reporting Guideline In BEhavioural Interventions (SCRIBE) check-list" (Tate et al., 2017) 2) Quality score assessed using "Risk of bias in pre-post studies" (Cummings et al., 2008)

Effects during SBT

Cardiorespiratory system

Cardiorespiratory outcomes was measured during SBT in seven studies (Table 3). Most studies used electrocardiogram (ECG) and respiratory belts to assess heart rate (HR), blood pressure (BP), breathing rate (BR), and QRS complexes (the waveform representing electrical activity of the heart). Zhang and colleagues (2017) found that six succeeding 3 minute-sessions significantly decreased BP and increased pulse transit time (the time it takes for a pulse wave to travel between two points in the body) during the sessions, compared to

normal breathing. During slow breathing, the amplitude of HR and BP oscillations increased. In addition, phase dynamics in cardiorespiratory coupling (coordination between cardiovascular and respiratory system) were improved suggesting a more efficient synchronization. Dick and colleagues (2014) showed that BP significantly decreased during a 20-minute slow breathing session, compared to normal breathing. During a 5-minute session, Fonoberova and colleagues (2014) found slow breathing to significantly increase sensitivity baroreflex sensitivity (the sensitivity of the baroreceptors in the heart that modulates HR and BP in response to BP), compared to baseline. In addition, there were significant improvements of blood flow to internal organs during slow breathing. Hinterberger and colleagues (2019) showed, during 7-minute periods of slow breathing, that the synchronization between BP and RSA (cyclic variation in HR that are synchronised with respiratory cycle) increased, suggesting improved coordination between HR and BP. Lin and colleagues (2014) found significantly increased HRV (variations in time interval between heartbeats), specifically in low frequency (LF; slow oscillations, influenced by both sympathetic and parasympathetic activity). Further, breathing rates and contributions in the high frequency range (HF; influenced by parasympathetic activity) of HRV were significantly reduced during slow breathing compared to pre- and post-training. Lehrer and colleagues (2003) showed significantly higher LF during a 20-minute session of slow breathing. The authors also found significant increased baroreflex sensitivity during the session, compared to rest periods. The LF spectral power was significantly greater during slow breathing, and the changes did not occur in the control group. Further, the baroreflex showed increased sensitivity in post-measurements compared to pre-measurements.

Central nervous system

Two papers assessed the cortical activity by assessing electroencephalogram (EEG) during SBT. Hinterberger and colleagues (2019) found that slow cortical potentials (SCP; gradual changes in electrical activity) in frontal and central areas to correlated with the respiratory cycle. Hsu and colleagues (2018) that slow breathing modulated cortical phase activity in the alpha range; the frequency of brainwave oscillations between 8-14 Hz that often are associated with relaxation. Further, slow breathing organized phase distribution of the MEG in a systematic pattern, while normal breathing had a random and unsettled distribution.

Psychological outcomes

Three papers on SBT measured psychological outcomes during SBT. Using a 0-100

scale of self-reported relaxation (VAS), Lin and colleagues (2014) found significantly higher relaxation scores after the session, compared to baseline. Hinterberger and colleagues (2019) measured naturalness, valence and arousal on a 3-point scale, and found that the maximal synchronization between RSA, SCP and respiration cycle was reported as the most relaxing one. Lehrer and colleagues (2003) found no significant between group differences in relaxation, using a self-report, scale instrument ("The Relaxation Inventory"; Crist et al., 1988).

Long-term effects

Cardiorespiratory system

Three papers assessed the long-term effects of SBT on cardiorespiratory outcomes. After a training program lasting for 8 weeks, Ma and colleagues (2017) found that 20 sessions of slow breathing for 15 minutes led to a significantly lower breathing rate, compared to pre-intervention measurements. Further, the intervention group had significantly lower cortisol levels after the 8 weeks of training. After five weekly 20 minute sessions of slow breathing, Sutarto and colleagues (2012) found significantly more LF activity in the HRV spectrum, compared to baseline. The same breathing frequencies was used by Lehrer and colleagues (2003), who found that 10 weekly sessions caused significantly higher baroreflex sensitivity after the intervention, compared to baseline.

Psychological outcomes

Long-term effects of SBT in psychological outcomes was measured by two papers. After 8 weeks (Ma et al. 2017), there was a significant reduction of negative affect in the "PANAS" scale (Watson et al., 2018) compared to baseline. There was no difference in positive affect. After 5 weeks (Sutarto et al, 2012), the intervention group showed significantly lower anxiety, depression and stress measured by the "DASS" questionnaire (Lovibonc et al., 1995). Note that the pre- and post-scores of anxiety and depression were sub-clinical.

Synthesized effects: Research papers on Holotropic Breathwork

Six papers examined effects HB. All six papers assessed psychological outcomes (See **Appendix 4** for description of each instrument). None of the papers examined biological effects.

Effects during HB

Psychological outcomes

Three studies assessed the acute psychological outcomes of HB. Using thematic analysis, Denisa (2003) found that participants with at least four prior practises of HB described the HB experience through eight categories: “physical feeling”, “body motions”, “emotions”, “energy”, “insights”, “life of the experiencing individual”, “circumstances concerning birth” and “crossing the limit of the common reality”. Puente (2014a) assessed the participants using the SDQ (Griffiths et al., 2006) and found that six (20,6%) of the total 29 participants had a “complete mystical experience” during the session. Ranging each scale between 0 and 1, the higher scores of the SCQ were found in “ineffability” (M=0.58, SD=0.2), “intuitive knowledge” (M=0.5, SD= 0.2) and “deeply felt positive mood” (0.46, SD=0.2). In another study using the SDQ, Puente (2014b) found that 13 (9,7%) of the total 124 volunteers had a “complete mystical experience” during the HB session. The higher scores were found in “deeply felt positive mood” (M=0.57, SD=0.2), “transcendence of time and space” (M= 0.43, SD= 0,2) and “internal unity” (M=0.43, SD=0.2). Rock and colleagues (2015) used the PCI to assess the phenomenological effects of the HB session. The authors found that the intensity and organisation of the “psygrams” during HB was significantly different from baseline scores. This reorganization did not occur in the control group. The HB group further reported a significantly higher level of altered consciousness than the control group, in addition to rating the experience as extraordinary and unusual.

The psychological effects immediately after a HB session was assessed by two studies. Assessing the PIL, Denisa (2003) found that the satisfaction level was significantly higher immediately after a HB session, compared to pre-session scores. Further, the participants had significantly lower scores in “Rigidity and dogmatism” measured by the “Value-Belief Q-Sort” after the session, compared to pre-session scores. Regarding POD, there were no significant differences in pre- and post-session scores. Somensula and colleagues (2017) measured level of stress (mild, moderate or severe) in nursing students after a HB session. They found that the number of students with moderate and severe stress decreased after one HB session (from 52% to 36%, and 20% to 16%, respectively), while the number of students with mild stress increased (from 28% to 48%). The significance level of the change was however not assessed.

Long term effects

Psychological outcomes

The long-term psychological effects of HB were measured by three studies. Miller and colleagues (2015) measured self-awareness using TCI, interpersonal problems using the IIP

and symptoms of psychological distress (sub-clinical) using SCL-90 after two sessions of HB. After three weeks, the participants reported a significantly lower scores in the "persistence" and "cooperativeness" in the TCI, and significantly increased "Paranoid ideation". After 15 weeks, the "persistence" score was still significantly lower than in pre-test. Further, the IIP total score was significantly lower, as well as specific scores of "overly accommodating" and "intrusive/needy" specifically. In the SCL-90-R, "hostility" was significantly lower and "paranoid ideations" significantly higher, compared to pre-test. Puente (2014a) assessed psychological distress using BSI, values using POI, purpose in life using PLT, death anxiety using the DAS, one month and six months after one HB session. After one month, the "Nature of Man" scale of POI was significantly increased. Six months after the HB session, the POI dimensions measuring "Time Competence", "Existentiality", "Nature of Man", "Synergy" and "Acceptance of aggression" was significantly higher than before the HB sessions. There were no significant changes in the other instruments, neither after one or six months. In the same study, the authors assessed how meaningful the experiences had been using the BPEQ. Five of the ten participants who filled out the BPEQ described the HB session as among the top five to ten most personally meaningful experiences in their live. Four of them rated the HB session as being the top five most spiritually significant experiences of their life. Five rated the HB to increase their sense of wellbeing or life satisfaction as "very much". Non reported decreased well-being or life satisfaction. Denisa (2003) compared scores in POI, PIL and Value Belief Q-sort between participants who had performed at least four HB sessions and a control group with no experience of HB. They found that experienced HB-performers had significantly higher POI scores of "Time Competence", "Orientation of Conduct", "Existentialism", "Emotional reactivity", "Spontaneity", "Self-esteem" and "Intimate contact ability" than the control group. In addition, the Value-Belief Q-sort showed that the HB group had significantly lower "Rigidity and Dogmatism" and "Conventional values".

Quality assessments: Research papers on Slow Breathing Techniques

Of the 9 included papers on SBT, five had within subject design and four had pre-post designs (See **Table 4** for study characteristics). The respective assessment tools indicated moderate to good quality in both categories. Checklist are displayed for within subject- and pre-post designs in **Supplementary Table 2** and **3**, respectively. For details on quality assessment, see **Appendix 5** in Supplementary Material.

Within-subject designs

The within-subject studies all had well-described scientific background, clearly states

aims and design. Interventions and statistical analyses were described in detail, as well as instruments and assessments. Weaknesses were mainly related to lack of randomization and blinding (due to intrinsic aspects of the intervention), lack of description of missing data and protocols. In addition, there were limited details on patients' sociodemographic variables. Only one of the within-subject studies assessed psychological outcomes (relaxation), and the scale had no description of validity or reliability. There were no measurements of more complex or psychological outcomes such as emotion or consciousness. Another weakness was that none of the within-subject papers were longitudinal.

Pre-post designs

The pre-post studies had rigorous scientific background and aims. The design and intervention were clearly stated. Description of statistical analyses were detailed, and both p-values and confidence intervals were given. Several of the pre-post studies assessed long-term effects, the longest time assessment being 8 weeks. The pre-post designs further enabled comparison with control groups and/or comparison strategies. For most papers, between group differences were analysed and reported. Instruments used for measuring cardiorespiratory and central nervous system effects were validated. Two of the papers assessed emotionality, using validated instruments (PANAS, DASS; see Appendix 3). Several studies combined physiological measurements with psychological measurement (either relaxation or emotion). The drop-out were less than 30% in all pre-post studies. The weaknesses were primarily lack of probability sampling, description of missing data management and absence of correlation analyses between multiple outcomes. None of the papers provided self-report questionnaires on more complex psychological outcomes.

Table 4: Study characteristics for papers on SBT

Study	**Study Design**	**Slow breathing group**	**Control group**	**Slow breathing technique**	**SBT details**	**Comparison Technique**	**Comparison details**	**Time-frame**
Zhang et al., 2017	Within subjects	55 (21 female, mean age: 27 SD = 6)	No control group	Paced breathing (14, 12.5, 11, 9.5, 8 and 7) BPM	3 min	Spontaneous breathing	3 min	Single session
Dick et al., 2014	Within subjects	10 (only male, mean age: 26 SD = 1)	No control group	Paced breathing	20 min	Spontaneous breathing	20 min	Single session

Fonoberova et al., 2014	Within subjects	24 (12 female. Mean age 21 SD = 0.9)	No control group	Paced breath (6 breaths/min)	5 min	Resting state	5 min	Single session
Hinterberger et al., 2019	Within subjects	37 (20 female Mean age: 34, SD = 15)		Paced breath (6, 8, 10, 12, 14 and again 6 cycle/sec)	42 min	Spontaneous breathing	5 min	Single session
Hsu et al., 2020	Within subjects	15 (3 female Mean age: 26.7, SD = 3.2)		0.125 Hz (8 s/breath)	5 min	Normal breathing (0.25 (4 s/breath)	5 min	Single session
Xiao Ma et al., 2017	Pre-post	19 (10 female, mean age: 30.16 +- 5.11)	Control group (10 female mean age: 28.2 , SD=3)	Paced breathing (self-paced)	15 min, 20 sessions	Non-intervention control group	Non-intervention control group	8 weeks
Sutarto et al., 2012	Pre-post	19 (Mean age: 35.6, SD: 10.4)	17 (Mean age: 37.1, SD= 9.8)	HRV biofeedback (6.5, 6.0, 5.0, and 4.5 breaths/min)	20 min	Controlgroup had same procedure, but no feedback on screen	20 min	5 sessions
Lin et al., 2014	Pre-post	30 (22 female. Mean age: 22.6, SD: 1.9)	28 (23 female. Mean age: 25.3, SD= 6.9)	HRV biofeedback (12, to 8, to 6 breaths/per min)	60 min	Autogenic training	60 min	Single session
Lehrer et al., 2003	Pre-post	25 (Mean age: 30.2, SD: 10.3)	32 (Mean age: 27.9, SD= 11.6)	HRV Biofeedback 4.5, 5, 5.5, 6, or 6.5 breaths/min, depending on individual optimal frequency	20 min	Waiting list	-	10 sessions

Quality Assessment: Research papers on Holotropic Breathwork

Of the six included studies on HB, two performed pre-post design and four had within-subject design (See **Table 5** for study characteristics). The within-subject papers on HB received either a low or moderate quality score and the pre-post studies on HB received a low quality

score (See **Supplementary Table 2, 3**). For the detailed quality assessments, see **Appendix 5** in Supplementary Material.

Within-subject designs

Aims were clearly described in every within-subject paper. Several psychological outcomes were investigated. Both immediate and long-term effects were assessed, with the longest time frame for assessing being 30 weeks. However of the six papers did not describe the HB intervention in detail. It is therefore difficult to know whether the setting, specific breathing pattern, role of the facilitator and guiding in the other five papers reflected the principles of Grof Holotropic Breathwork ©. Further, several of the studies did not provide sufficient scientific background or references in their literature review. Statistical analyses were often not described in detail, or not described at all. Only two papers (Puente, 2014a; and Rock et al, 2015) report psychometric properties for the utilized psychological instruments. The remaining five papers do not report reliability or validity for the assessed questionnaires. None of the papers attends to adverse effects of the intervention.

Pre-post designs

Both pre-post studies used a control group as comparison. However, there were several weaknesses found in the pre-post studies on HB. Convenient sampling was used in both papers, and only one reported how and from what population participants were included. None of the papers justified sample size to obtain adequate power. There was no blinding or randomization (which would be difficult due to the nature of the intervention). Though both papers stated comparability between groups, data was not given. These challenges the validity of the statistical analyses, as t-tests were used in both papers. In addition, neither report on normality or variance in the data. HB intervention was not described, neither was setting, role of facilitator or guiding. None of the studies did several pre- or post test, and only one of the two papers had both pre- and post-test. Instruments were not described in terms of reliability or validity. Missing data was not described, nor was attrition rate.

Table 5: Study Design for HB

Study	**Study Design**	**Holotropic breathwork group**	**Control group**	**Holotropic breathing details**	**Comparison Technique**	**Timeframe**
Somensula et al., 2017	Within-subject (only post assessment)	50 (demographics not provided)	50 (demo not provided)	No details provided. No reference to	No intervention control group	Single session (unknown timeframe)

				the original procedure by Grof		
Rock et al., 2015	Within subject, counterbalanced	32 (60% female. Mean age: 43.1, SD= 9.05)	-	Orignal Grof Holotropic Breathwork. Procedure and details described.	"Sitter": Observing group-partner perform breathwork	Single session + counterbalancing session (2.5 hours each)
Denisa, 2003[1]	Within subject	11 (demographic not provided)	-	Referes to Grof Holotropic Breathwork. No procedure or details provided.	-	Single session (unknown timeframe).
	Between subjects	36 (demographic not provided)	34		No intervention control group	Four HB sessions (unknown timeframe)
Puente, 2014a	Within subjects	16 (56% female. Mean age: 43.6, SD = 13.6)	-	Referes to Grof Holotropic Breathwork. No procedure or details provided.	-	Single session (unknown timeframe)
Puente, 2014b	Within subjects	134 (7% female. Mean age: 32.9, SD = 8.8)	-	Referes to Grof Holotropic Breathwork. No procedure or details provided.	-	Single session (unknown timeframe)
Miller & Nielsen., 2015[2]	Within subject	All participant: 20 (mean age 44.2); 50% female	-	Referes to Grof Holotropic Breathwork. No procedure or details provided.	-	Four HB sessions (two weekend-workshops; 12 weeks between).
	Within subject	Participants with no experience (n=9)	-		-	
	Within subject	Experienced participants (n= 11)	-		-	

Notes: 1) Denisa (2003) described two designs in one paper, examining both changes before and after within subjects (n=11) and between experienced breathers (n = 36) and a control group (n = 34). 2) Miller and Nielsen (2015) examined the effect both for all participants (n=20), and in the subgroups of novices (n=9) and experienced participants (n=11).

Discussion

This study reviewed and compared research articles on SBT and on HB. The aim was to examine how the biomedical, positivistic approach to SBT and the phenomenological, transpersonal approach to HB shaped each knowledgebase. The findings implies that the research bases differ in several aspects, primarily in quantity, methodological quality and which outcomes are conceptualized and measured. The result further suggests specific strengths and weaknesses to be associated with each research base. In the following, these will be discussed, as well as implications for improving future studies on breathing techniques.

How might the current knowledgebase on SBT be influenced by positivism, and what strengths and weaknesses are evident in this body of research?

Several characteristics in the SBT studies reflects a positivistic, biomedical approach. The extensive number of studies on SBT suggest empirical research to be pivotal for this knowledge base. In addition, the SBT papers were characterized by comprehensive assessments of objective, quantifiable outcomes, and detailed statistical analyses. Some methodological limitations were found. The main issues in within-subject designs were limited information on patient characteristics, setting and protocol, lack of information on missing data and procedural changes (See Supplementary Table 1). In pre-post designs, the main issues were lack of probability sampling, randomization into groups and justification of sample size (See Supplementary Table 2). Despite these limitations, all SBT papers were evaluated to have either moderate or high methodological quality.

Rigorous assessment of objective, biological data could be a strength to the positivistic approach to breathing techniques. The review demonstrated a significant focus on physiological effects of SBT, specifically in the cardiorespiratory system and the central nervous system (Table 3). Both Zhang and colleagues (2017), Dick and colleagues (2014) and Lehrer and colleagues (2013) found decreased blood pressure as an outcome of SBT, which has been replicated in similar studies (Radaelli et al., 2004; Joseph et al., 2005). Further, several of the included papers found acute- and long-term increments in baroreflex sensitivity, HRV, and LF activity, as well as decrements of HF activity (Fonoberova et al., 2014; Lin et al., 2014; Lehrer et al., 2003; Sutarto et al., 2015). The findings correspond to previous studies on cardiorespiratory outcomes of SBT (Pitzalis et al., 1998), specifically by suggesting a notable involvement of the parasympathetic branch of the autonomic nervous system

(Jerath, 2006; Russo et al., 2017). Further, both studies using EEG found SBT to moderate cortical activity. Hsu and colleagues (2020) showed that slow breathing widespread cortical phase activity in the alpha range, and phase coherence was reduced. A modulating effect of SBT was also found by Hinterberger and colleagues (2019), who demonstrated that the respiratory cycle correlated with slow cortical potentials in frontal and central areas. The increased alpha activity is coherent with several other EEG findings during SBT (Fumoto et al., 2004; Park & Park, 2012).

A limitation to the SBT research base, was the scarcity of psychological assessments. This could imply a potential downside to the positivistic approach: compromising subjective experiences for objective, biological assessments. Several papers did not assess psychological outcomes at all. Of the five studies that did, only three assessed subjective experiences during SBT. In addition, these merely assessed relaxation; two of which using a 0-100 scale (Lin et al., 2014) or a 3-point scale (Hinterberger et al., 2019) without validation. Regarding long-term psychological outcomes, positive emotions, negative emotions, and stress was assessed by two of the nine papers (Xiao Ma et al., 2017; Sutarto et al., 2012). Both found significant reductions of negative emotions. However, the outcomes were only assessed through scale ranking (PANAS and DASS). Such instruments provide no conceptualization of more complex, nuanced and in-depth subjective experiences such as alterations of consciousness, perception, or mindfulness.

How might the current knowledgebase on HB influenced by phenomenology, and what strengths and weaknesses are evident in this body of research?

Several findings imply phenomenology and transpersonal psychology to be influential for the research papers on HB. In these traditions, introspection of subjective experiences is central for understanding the effects of an intervention. This viewpoint is mirrored in the HB studies. All HB papers examined subjective experiences using comprehensive psychological instruments. Transcendental experiences were assessed in almost all of the papers, i.e., altered consciousness, change in perception of self, time and space, as well as increased spirituality, mystical experiences and internal unity. Existential aspects such as fear of death and meaning of life were also assessed, as well as humanistic values such as self-actualization and self-acceptance. The conceptualizing of complex emotions, internal states, and transpersonal experiences in this research paradigm, provides the knowledgebase on HB with phenomenological data on both acute and long-term outcomes. Many of the results were coherent between studies.

In terms of acute effects, increased awareness of emotions was found by several studies, both of sorrow, fear and anger (Rock et al., 2015; Denisa, 2003), deeply felt positive feelings (Puente 2014, ab, b; Denisa, 2003). This could be related to the activating effect of hyperventilation, evocative music and turning ones attention inward though closing the eyes. According to his theory, the emotions that arises during HB are supressed material that are only accessible through altered consciousness. This is related to how a NSC is less controlled by the rational mind and allows for deeper levels of the brain to be experienced. This could related to the participants reporting it as difficult to describe the experience in words (Rock et al. 2015, Puente, 2014, a), as well as an experience of reduced "rationality" during the session. Several other findings suggest such NSC to be evident. NSC are often characterized by a shift in perception of self, time and space, and a change from the everyday experience of the world, and an increased experience of meaning and presence (Timmerman et al., 2023). In the HB studies, this could correspond to current findings of participants describing "transcendence of time and space (Puente, 2014b), "crossing the limits of common reality" (Denisa, 2003) and a significant higher level of altered consciousness compared to the control group (Rock et al., 2015). Denisa (2003) also found HB breathers to report significantly higher satisfaction in life immediately after a HB session, corresponding to feelings of "intuitive knowledge", "internal unity", "insights" and purpose in life reported in two studies by Puente (2014a,b). According to Grof, these positive effects of insight and meaning indicates the processing of challenging emotions and memories, and releasing physical, cognitive or emotional blockages (Grof & Grof, 2010).

Further, HB were associated with several positive long-term effects. In terms of relational effects, Miller and Nielsen (2015) found decreased total IIP score and Denisa found increased communication skills (2003). This relates to a study of HB by Holmes and colleagues (1996) using clinical samples, where the breathers reported increased sense of connectedness with others after the session. These prosocial effects could be related the processing of challenging material combined with a safe group environment. Beneficial effects of group settings have been found for other trauma therapy (Lewis et al., 2020), as psychological debriefing immediately after trauma exposure can be helpful for normalizing and understanding reactions (Eriksson & Trice, 2001). However, this explanatory framework remains mere speculations for HB, as more evidence is needed to support such hypothesis. Further, changes in values and behaviour, such as reduced rigidity, aggression and dogmatism

were reported in several studies, in addition to higher spontaneity (Denisa, 2003; Miller & Nielsen., 2015; Puente 2014, a, b). Such findings could be interpreted in relation to the stress reduction found in both non-clinical (Somensula et al., 2017) and clinical studies of HB (Uthaug et al., 2022), as high level of stress are associated with both aggression and rigidity (Summer & Winberg, 2006).

Other long-term effects involved increased purpose in life (Puente 2014a). The participants further HB session as a highly meaningful event, with positive impact on their life (Puente, 2014a). These is coherent with a study by Uthaug and colleagues (2022), who found significantly higher scores of life satisfaction four weeks after HB. Such findings could be linked to the state of NSC. Other NSC-inducing practises, such as meditation and psychedelic experience, are also associated with long-term outcomes of increased well-being (Kettler et al., 2019), self-actualization and meaning (Katyal et al., 2022), as well as positive attitudes towards self and others (Breeksema et al., 2023). In addition, reduction of stress, anxiety and depression are linked to such practises (Nikolaidis et al., 2023; Breeksema et al., 2023). These findings not only display NSC as a central aspect of HB; they also add to the literature of associations between NSC-inducing practises and positive therapeutic effects.

Unfortunately, a general lack of studies on HBs restricts the overall knowledgebase. Most of the included HB papers were not available through the chosen search engines and had to be included manually. In addition, the papers on HB had generally lower methodological quality than SBT. Several issues were prevalent, involving lack of protocol or description on the HB procedure, lack of references in the scientific rationale, missing or few reported patient characteristics and lack of sufficient description of statistical analyses. These weaknesses challenge the generalizability of the findings, as heterogeneity could exist between HB procedures in different studies, between groups within studies, and between a sample and the general population. For the between-group study, the lack of statistical analyses assessing baseline differences between control groups and HB groups are especially problematic, as the effects found are potentially related to existing differences between HB practitioners and non-practitioners. Further, the limited focus on both descriptive and analytical statistics makes it possible for the findings to be a result of chance, and not effect. Several of the instruments lacked independent validation (PCI; Pekala, 1985; VBQ; Hruza et al., 1969; POD; Shostrom 1964; BPEQ, Griffiths et al., 2006), though some of the questionnaires were evaluated to have sufficient reliability and validity (PLT; Crumbaugh, 1968; SCQ; Griffiths et al., 2006; DAS; Templer, 1970; TCI; Cloninger, 2004; IIP; Horoqitz,

2008; SCL-90-R; Derogatis, 2009; BSI; Derogatis, 1993). The PCI and BPEQ have further been rated to have sufficient psychometric abilities according to the authors own validations, but there is however need for future studies to independently validate several of the instruments used in the included studies. (See Appendix 3 for more detailed information).

The lack of methodological quality in non-clinical samples, could potentially be a reason for the absence of clinical studies. In this way, the lack of quantity and quality in HB papers stagnates knowledge on the clinical value of HB, as clinical psychology is a evidence based practise (American Psychology Association, 2002). The methodological challenges in the phenomenological approach to HB papers could ultimately hinder integration and utilization in psychotherapeutic settings.

Implications

Improving the knowledgebase on SBT

Based on the current findings, future studies on SBT could benefit on including more in-depth examinations of acute and long-term subjective experiences. There are several reasons why this could improve the knowledgebase on SBT. First of all, the cardiorespiratory findings during SBT are associated with a range of psychological correlates that were not assessed in the included papers. Increasements in HRV and baroreflex sensitivity are associated with increased psychological flexibility, emotional regulation and mental well-being (McEwan et al., 2021; Pinna et al., 2020; Williams et al., 2019; Thayer et al., 2009; Appelhaus et al., 2006), as well as reduced anxiety and depression (Kothgassner et al., 2022; Tolin et al., 2020; Zucker et al., 2009). Increased HRV also corresponds to increased vagal tone and parasympathetic dominance (Laborde et al., 2022), which can facilitate ones psychological ability to adapt to external and internal challenges (Lehrer & Gevirtz, 2014; Kobele et al., 2010). Assessing such subjective experiences could be valuable in future studies.

The cortical findings of increased alpha activity emphasize another relevant psychological assessment, namely mindfulness. Increased alpha power is found correlated with mindfulness during meditation, as well as other breathing techniques (Tang et al., 2019; Bing-Canar et al., 2016: Chan et al, 2006). It is therefore plausible that similar subjective experiences are evident during SBT. Mindfulness is further related to improved positive moods, reduced negative emotions, and decreased stress hormones (Tang et al., 2015; Hofmann et al., 2017), and mindfulness-based interventions have been linked to decreased

depression and anxiety in a vast amount of research (Hofmann et al., 2017; Zemestani et al., 2020; Nissen et al., 2020; Hearn et al., 2020; Song et al., 2015; Falsafi, 2016). This underlines the potential value of SBT in promoting mental health, and the value of expanding our knowledge on these effects.

Another improvement relevant for future studies on SBT, is assessing alterations of consciousness. In a study from 2022, Zaccaro and colleagues used the "Phenomenology of consciousness inventory" (PCI; Pekala, 1991) to measure whether slow nasal breathing alternated the participants consciousness. In PCI, an altered consciousness is measured based on twelve phenomenological dimensions, i.e., "altered state", "volitional control", "rationality, "attention", "memory" and "affect" (See Appendix 4 for details on PCI). The participants reported that slow nasal breathing caused a change in perception of body and time and increased experience of meaning, suggesting an altered state to be evident (Zaccaro, 2022). Considering that several of the papers included in this review stated nasal breathing as default, it is possible that similar alterations of consciousness could be present during SBT. These altered states are often referred to as non-ordinary states of consciousness (NSC; Timmerman et al., 2023). Timmerman and colleagues defines NSC as "experiences that arise spontaneously or are induced by practices and/or rituals, and can have considerable cultural and eudaimonic (i.e., denoting well-being and meaning in life) significance" (2023). NSC have been found in practises such as meditation (Mielliere et al., 2018), hypnosis (Lemercier & Terhune; 2018) and psychedelics (Nikolaidis et al., 2023; Preller et al., 2016), as well as fast breathing techniques (Uthaug et al., 2021). An common feature for such NSC-inducing practises, it that the participants experience a shift from the taken-for granted world of life to a different perception of time and/or space, as well as sense of agency in ones own life (Timmerman et al., 2023). The reason why it is important to examine whether SBT induces NSC is because these states are associated with several positive psychological effects. Research on meditation and psychedelic experiences have demonstrated associations between NSC-inducing practises and reductions of stress (Khoury et al., 2015)), anxiety (Chen et al., 2017; Valentine et al., 2019; Goldberg et al., 2018) ,) chronic pain (Milling et al., 2021), and psychological distress in terminally ill patients (Schimmel et al., 2022). Further, they are found linked to increased well-being and prosociality (Kettner et al., 2019;), nature connectedness (Haijen et al., 2018) and quality of life (Hilton et al., 2017). NSC-inducing practises are further associated with increased spirituality and positive attitude towards self

and others (Breeksema et al., 2023), experience of purpose and sacred meaning (Zaccaro et al., 2021) and reports of self-realization and self-actualization (Katyal et al., 2022).

Finally, measuring psychological data could be performed as an intervention in itself by increasing the breather's interoceptive awareness. Interoception reflects one's ability to sense and attend to sensations inside the body and have been found closely related to emotional regulation (Price & Hooven, 2018). Depression, anxiety and trauma is often associated with lack of interoception (Khalsa & Lapidus, 2016), causing feelings of disembodiment, lack of self-awareness and decrease one's ability to assess internal states (Brom et al., 2017; Lanius et al., 2020; Rabellino et al., 2018). This can have a negative impact on ability to access one's own emotions and needs, further challenging adequate behaviour for emotional regulation. Several psychotherapeutic theories therefore emphasize the value of learning to identify and describe internal states when recovering from mental illness, as this can increase self-awareness and emotional competence (Brom et al., 2017; Levine & Kline, 2012; van der Kolk, 2006). Considering the increased HRV and alpha activity during SBT, it is highly lightly that the technique could help facilitate positive internal states. By encouraging interoception, one could examine whether this increases the breather's ability to name and understand internal states. For future studies of SBT on clinical population, such assessments could further provide terminology for both the therapist and the patient to use during such exercises.

Improving the knowledgebase on HB

Increasing methodological quality is a pivotal for improving the knowledgebase on HB. Specifically, sufficient description of the intervention should be provided in all papers to ensure comparable effects. Further, both descriptive and analytic statistics should be prioritized. Collecting necessary data on demographic characteristics such as age, sex, socioeconomic status, and education will enable sensitivity analyses of effects, and provide valuable data on how these variables might influence experiences. In within subject designs, it is crucial to assess and provide sufficient data on pre- and post-assessments of outcomes, and to conduct statistical analyses comparing these values. This could further be examined using sensitivity analyses controlling for demographic variables. In between subject designs using control groups it is highly important to measure demographic variables and baseline psychological variables between groups before the intervention. In addition, the groups should be investigated for level of prior experience with HB. This is to ensure that demographic variables, psychological outcomes and level of experiences is comparable between groups

before the intervention, so that effects are not related to already existing differences between the experiment group and the control group. In designs using the "sitter" condition as a control group, one could improve effect assessment by ensuring equal distributions of demographic variables in each group. There is however the problem with the counterbalanced design, as the "sitter" group can be influenced by observing the practise before conducting it themselves. Lastly, developing and validating adequate instruments for assessing transpersonal outcomes is important for all interventions targeting these variables.

Another important implication for futures studies, is examining whether there are biological correlates to the phenomenological descriptions. There are reasons to believe that HB could influence both cardiorespiratory and cortical activity. In a study of "Holorentic Breathwork" - a technique highly similar to HB - significant increasement of HRV were found 15 minutes after the session (Cervantes & Puente, 2014). HB is further associated with prosociality, reduction of aggression and psychological flexibility, which both are outcomes associated with increased HRV (Quantina et al., 2012; Grol & Readt, 2020). Further, assessing activity in the central nervous system using EEG and fMRI is relevant. HB would most lightly induce temporal neurophysiological changes, considering how hyperventilation correlates with several changes in neural activity (Agadzhanyan et al., 2003; Jensen et al., 2002; Settakis et al., 2002) such as reduced MR signal in frontal, occipital and parietooccipital cortex (Posse et al., 1997), as well as decreases of blood flow velocities to cerebral arteries, increase in capillarity Ph, Po2 and oxygen saturation (Settakis et al., 2002).

Further, there are several biological theories for HB that needs to be examined based on physiological data. One such framework is posed by Rhinewine and Williams (2007). They claim that hyperventilation can cause "transient hypofrontality" - a brief period of lowered activity in the frontal cortex due to cortical metabolic changes (2007). Such higher order brain areas are central for emotional regulation (Dixon et al., 2017), as well as higher order functions such as language (Klaus & Schutter, 2018; Bourguingnon et al., 2018) and cognitive control (Widge et al., 2019; Funahashi & Andreau, 2013). This perspective could explain the increased range and intensity of emotions during HB, as well as experience of "reduced rationality" and difficulty with describing the experience in words. However, this hypothesis remains at a theoretical level, as there are no current empirical evidence to validate this theory. Therefore, assessing cortical and sub-cortical activity using EEG or fMRI during HB would be highly valuable. Such assessments could further be important for understanding the NSC reported during HB. This is strengthened by the fact that similar alterations in

higher-order brain areas seem to be evident in other NSC-inducing practises. For instance, serotonergic psychedelics have been thought to cause reductions of influence from higher-order brain levels on bottom-up information (Zamani et al., 2021) Assessing cortical and sub-cortical measurements during HB could therefore add to our biological understandings of both HB specifically and of NSC's in general.

Further, EEG and fMRI assessments could elucidate the role of the Default Mode Network (DMN) in both acute and long-terms effects of HB. The DMN is a functional brain network relevant for self-referential thinking, introspection and processing of internal thoughts and emotions (Borserio et al., 2021). DMN is also central in functions such as autobiographical episodic memory (remembering specific episodes and memories one has experienced), prospection (imagining the future), spatial navigation (imagining one's position in the room) (Bucker et al., 2008). In terms of acute effects of HB, participants describe change in perception of self and body awareness, transcendence of time and space and encounters with early memories (Puente, 2014a, b; Rock et al.,2015). It would therefore be interesting to examine whether these experiences are associated with acute alterations in DMN activity. The DMN could also be relevant for the long-term effects of HB. Increased DMN activity have been found associated with Depressive symptoms such as rumination, negative perceptions of oneself repetitive, and repetitive thought on negative past- and future events (Sheline et al., 2009; Hamilton et al., 2015; Borserio et al., 2021). In contrast to this, HB participants report long-term outcomes of increased feeling of presence, inner directiveness and well-being (Puente, 2014a,b), as well as increased spontaneity and orientation of conduct. One hypothesis is that HB is associated with both reductions of repetitive and rigid perceptions and behaviour and with decreased DMN activity. Physiological measurements are however crucial for examining whether these hypothesises are evident.

Limitations to the current review

This review assumes that the research on SBT is representative for the positivistic research paradigm, while HB can exemplify a phenomenological, transpersonal approach. This can be criticised as overgeneralizing. The theoretical and historic background for breathing techniques used today are often influenced by various traditions and geographical areas. Further, SBT has roots in ancient, eastern practises, and portraying it as a concept of modern, western origin is therefore not correct. However, the current findings do suggest that

the modern *approach* to SBT in science is somewhat biological oriented. And though there are no explicit statements of biological psychology being the guiding framework for the included studies on SBT, the types of outcomes suggest a positivistic and physiological oriented perspective. Regarding HB, Grof himself describe transpersonal psychology as central for the practise (Grof and Grof, 2010). In addition, several of the papers on HB does state transpersonal psychology as a cornerstone for this breathing practise.

One could argue that the comparative nature of this review is unveiling, as SBT and HB differ in what acute effects they aim to achieve and how many elements are involved in the practise. SBT is performed to increase relaxation and parasympathetic activation, and mainly involve breath regulation. HB acutely increases physiological and emotional activation. In addition, HB is a complex practise combining both breathing regulation, music, and movement. Comparing SBT and HB on their specific effects is therefor in itself somewhat futile. However, the purpose of this review was not to compare effects, but to compare how the different theoretical traditions influences the empirical examination of these techniques.

Another limitation is related to the lack of focus on underlying epistemology and ontology of the transpersonal and positivistic approaches to psychology. This limitation emerged due to a broad research question, compromising depth and detail on philosophical controversies. Future reviews might benefit form only discussing the practical consequences of different epistemologies.

Regarding limitations in method for the current review, the validity of the quality assessments is greatly reduced by the lack of multiple reviewers and interrater reliability. Despite using quality assessment tools adapted from several other reviews (Tate et al., 2016, Cummings et al., 2008), independent assessment by several reviewers would provide a more reliable evaluation. This is especially evident for the scoring of single-case designs using SCRIBE Checklist, as there is no formal consensus on how to range or categorize levels of quality. The review therefore adapted an approach performed by Zaccaro and colleagues (2019) in a similar review, involving classifying each SCRIBE item on a yes or no scale. The reviewer herself (V.K.N) categorized the SCRIBE scores into low, medium, and high, which is unfortunate for the validity of the quality assessments.

The limited number of clinical studies on HB caused this review to only include papers on non-clinical populations. This reduces the ability of the review to assess therapeutic

effects on clinical populations, which is necessary to give more precise conclusions on the clinical implications of SBT and HB. Future reviews should address HB papers involving clinical samples to address such issues.

Lastly, not all of the checklist items of the PRISMA table were met. Assessing detailed quantitative statistics such as effect sizes, confidence intervals and missing data analysis could improve future reviews of breathing techniques.

Conclusion

The current findings implies that the unalike research paradigms in SBT and in HB generates several differences between the corresponding research bases. The knowledgebases on each technique primarily differed in quantity, methodological quality and in what type of outcomes were prioritized. Specifically, the SBT research base consisted of numerous studies with overall sufficient methodological quality. The papers were characterised by extensive measurements of biological outcomes. Psychological outcomes were less comprehensive, and mainly involved measurements of relaxation, positive and negative affect. More complex emotions and subjective experiences were not examined. This is highly problematic, as there is evidence that SBT could be associated with mindfulness, alterations in consciousness and interoceptive awareness – all of which are subjective experiences with potential therapeutic value.

Conversely, studies on HB assessed detailed phenomenological and transpersonal outcomes such as non-ordinary states of consciousness (NSC), spirituality and altered perceptions, as well as purpose in life, self-actualization, and personality. However, none of the HB papers measured biological outcomes. This causes all biological frameworks for HB to remain at a theoretical level. In addition, HB papers were inferior to SBT papers both in terms of quantity and methodologic quality, which could be linked to this research paradigms having different empirical traditions. This challenges the validity of HB findings in non-clinical samples. This could further be related to the lack of clinical studies of HB, leaving the clinical value largely unexplored.

This polarization between approaches to breathing techniques fragmentates our knowledge and utilization of both SBT and HB. In future studies, scientists should consider the necessity of an integrated approach when selecting outcomes. There is much value in expanding the phenomenological knowledge of SBT, and biological understandings of HB. In

addition, sufficient methodological quality must be conducted in all studies on breathing techniques. By combining the strengths from each approach, this could broaden the knowledge of health benefits associated with these techniques. Finally, we could expand our understanding of how phenomenology and biology are connected.

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Supplementary Material

Appendix 1: Search Terms

Slow breathing techniques:
Slow breath
Slow breathing
Deep breath
Deep breathing
Breath exercise
Breath technique

Holotropic Breathwork:
Holotropic Breathwork
As this is a distinct technique, using the specific term was necessary to identify studies using the precise intervention developed by Grof © (Grof & Grof, 2010).

Cardiorespiratory system outcomes:
Cardiorespiratory coupling
Heart rate variability
HRV
Respiratory sinus arrythmia
RSA

Central nervous system outcomes:
Electroencephalogram
EEG

Psychological outcomes:
Emotion
Stress
Well-being
Consciousness
Awareness

Appendix 2: Details on cardiorespiratory- and central nervous system outcomes found in SBT papers

Most papers used electrocardiogram (ECG) to assess QRS-complexes (the waveform representing electrical activity of the heart), heart rate variability (variations in time interval between heartbeats), cardiorespiratory oscillations (variations in ECG waveform that are influenced by respiratory cycle), respiratory sinus arrhythmia (RSA; cyclic variation in HR that are synchronised with respiratory cycle) and cardiorespiratory phase coupling (CRC; coordination between cardiovascular and respiratory system). In the context of HRV-data, several papers extracted both low frequency (LF; slow oscillations, influenced by both sympathetic and parasympathetic activity) and high frequency (HF; influenced by parasympathetic activity). In addition – pulse transit time was assessed, which is the time it takes for a pulse wave to travel between to points in the body. These measurements also

provided data for several studies to assess baroreflex sensitivity (the sensitivity of the baroreceptors in the heart that modulates HR and BP in response to BP).

For the central nervous system, electroencephalogram (EEG) was used to measure electrical activity in the cortical neurons of the brain. These communication between neurons produce rhythmic oscillations, which is defined as alpha (8-12 Hz), beta (12-30 Hz), gamma waves (30-100Hz) depending on their specific range. Slow cortical potentials refer to slower changes in electrical potentials that occur over longer periods of time.

Magnetoencephalogram (MEG) was used to measure magnetic fields of electrical activity in the brain. In this analysis, they used time-frequency representation of respiration locked MEG to examine changes in neural oscillatory activity over time and across frequency bands. They also used unity-based time normalization to align and normalize timing of MEG data to respiration cycle.

Appendix 3: Details on psychological outcomes found in SBT papers

The Relaxation Inventory (Crist et al., 1989):
This is a self-report measure to measure the effects of interventions to increase relaxation. It is a 45-item questionnaire with three scales representing somatic, cognitive, and behavioural manifestations of anxiety. According to Crist and colleagues (1989) the scale demonstrates adequate internal consistently.

Side effects of Relaxation Scale (Kotsen et al., 1994)
Assesses common adverse experiences of people undergoing various kind of relaxation training, such as anxiety, intrusive thoughts, fear of losing control.

Visual Analogue Scale (VAS; Lin et al., 2014)
VAS is a self-report scale to rate the subjective relaxation score, rnaging from 0 (not at all) to 100 (vert relaxed).

Depression, Anxiety and Stress Scale (DASS; Musa et al., 2012)
DASS is a self-report instrument designed to measure and distinguish between depression, anxiety, and stress. Each contains 14 items, divided into subscales of 2-5 items with similar content. The anxiety scale assesses autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect. Stress scale assesses levels of chronic nonspecific arousal, such as relaxing, nervous arousal agitation, irritableness, and impatience. The depression scale measures dysphoria, hopelessness, devaluation of life, self-depreciation, lack of interest, anhedonia, and inertia. The items range from 0 to 4, and scores are calculated by summing all items. DASS is shown to have convergent and disciruminnat validity, and acceptable psychometric properties (Akin et al., 2007)

PANAS (Watson et al., 1988)
This self-report scale consists of 5-point likert scale that assesses feelings during the last week. PANAS includes 20 self-report items that are devided into positive affect (PA) and negative affect (NA). It has proven to have high internal consistency, and is stable and reliably across cultures (Thompson, 2007)

NCT (Ma et al., 2017)
The NCT consist of four test sheets that evaluates attention sustainability. Attention

sustainability is reflected by the scores generated by the accuracy in the test. Ech sheet has 200 single digits with symbols below or above. Targets are 9 digits with two symbols below, above or either side. Participants will cross out targets with a slash and ignore targets placed subsequent to “5” as quickly as possible. There is a 10 to 20 second rest between two sheets. The final score is provided by the sum of correct number of target digits in each sheet.

Appendix 4: Details on psychological outcomes assessed in HB papers

Phenomenology of Consciousness Inventory (PCI; Pekala, 1985)
The PCI is a self-report instrument developed to “operationally define, map states and altered states of consciousness” (Pekala, 1985). The questions are designed to measure effects during the relevant experience. Its aim is to tap into different phenomenological changes that can be experienced in situations associated with altered states of consciousness, such as meditation, hypnosis and out-of-body experiences. The PCI consists of 53 items consisting of 12 major dimensions of phenomenological (as in subjective) elements (e.g., positive effect, altered experience, visual imagery, altered states of awareness (ASA), rationality) and 14 minor dimensions (e.g., fear, joy, altered body image, absorption). The PCI-scores produces “psygrams” (covariation matrices) that gives information on a) average insanity value (from 0-6) on each dimension and b) strength of association between pairs of major dimensions. A “psygram” is made by producing a corelation matrix of the 12 major dimensions. Non-significant corelation coefficients ($p > .05$) are not used. Significant r values are converted to r^2 values, which further are converted to percentages. Each line linking a pair of major dimensions involves 5% of the r^2 variance in common. Therefore, the higher r^2, the stronger the coupling between a pair of dimensions are. These are mapped into figures providing a visual description of what intensity and interaction of dimensions are prevalent in a specific experience.

There are few validations on the PCI available. An assessment of reliability and validity in the PCI during an altered state of consciousness (hypnosis; Pekala, 1991), showed conflicting results in regards of reliability index and validity. Pekala (1991) found that the Pearson r coefficients, difference scores and coefficient alpha results indicated acceptable reliabilities for the subdimensions of the PCI. However, these results were derived from a still-sitting condition, and not under the influence of a altering consciousness. Further, the quality assessment was performed by the author himself. Though there are strengths related to the complexity and depths of data, the PCI should be further validated to map the psychometric abilities.

Purpose in Life Test (PLT; Crumbaugh, 1968)
This questionnaire measures the extent to which the participant perceives life to be meaningful. Its theoretical underpinnings are based on concepts of Victor Frankl and his “logotherapy” (Frankl, 1973). The questionnaire has 20 items, each rated on a seven-point Likert scale. The sum score can be between 20-140, and scores under 90 indicates lack of meaningful life. Scores between 90-105 are considered a “indifferentiation area”. Scores up to 105 indicates a meaningful life, having clear goals and a sense of purpose.

PIL scores are associated with life-satisfaction, happiness, self-acceptance, and emotional

stability, negative with depression and anxiety (Crumbaugh and Henrion 1988; Robak and Griffin 2000).

There are several validations available for PIL (Crumbaugh and Henrion, 1988; Hutzell, 1988). Internal consistency and split-half reliability ranges from .70 to .90. However, PLT have been criticised to assess several dimensions that does not reflect the meaning of life to the same extent. The short-form in measured to have higher validity and psychometric abilities.

Values-Belief Q-Sort (Hruza et al., 1969)
This self-report instrument assesses various attitudes and beliefs towards reality and science, such as "Rigidity and Dogmatism", "Psychedelic Spectrum", "Conventional Values", "Inadequate approach to reality" and "Scientific rigidity". There are few sources of validation or further description of the instrument, which sets the psychometric abilities of the instrument into question.

Personal Orientation Dimensions (POD; Shostrom, 1964)
POD consist of 150 forced choice pairs of statements involving comparative value and behaviour judgements. It is based on Maslows conception of the self-actualizing person and provides a measure of two basic scales of personal orientation. The first one is "Inner Directed Support" (IDS) and the second "Time Competence" (TS). IDS measures the degree to which actions originate in the person or as a reaction to others. TS measures the level of being present-oriented, or whether the person is more oriented to the past or future. In addition, it provides ten subscales measuring conceptually important elements of self-actualization: Self-Actualizing Value (SAV), Existentiality (EX), Feeling Reactivity (FR), Spontaneity (S), Self-Regard (SR), Self-Acceptance (SA), Nature of Man (NC), Synergy (SY), Acceptance of Aggression (A) and Capacity for Intimate Contact (C). POD Has been criticized for failing in generating sufficient amount of research, and there are difficulties related to test construction, theoretical justification and interpretation.

States of Consciousness Questionnaire (SCQ; Griffiths et al., 2006)
This instrument is a 100-item self-assessed questionnaire which measures alterations in consciousness and mystical experiences. The theory is based on the "psychology of religion" by Stace (1960). It consist of scales for seven domains of mystical experiences: "Internal unity (pure awareness; a merging with the ultimate reality)", "external unity (unity of all things; all things being alive)", transcendence of time and space, "ineffability and paradoxicality (claim of difficulty in describing the experience in words)", "sense of sacredness, "noetic quality (claim of intuitive knowledge of ultimate reality)" and "deeply felt positive emotion (joy, peace and love)". Each scale is expressed as a proportion of the maximum possible score, which is 1. Phanke (1969) considered a "complete mystical experience" to involve each scale to be at least 0.6 on either internal or external unity, transcendence of time and space, ineffability, sense of sacredness, noetic quality and deeply felt positive mood. Though used and validated by Griffiths and colleagues (2006), it is not independently validated.

Death Anxiety Scale (DAS; Templer, 1970)
The DAS is a self-report True-False choice questionnaire. It consists of 15 items reflecting beliefs, concerns and attitudes revolving death. The total score can range between 0 an 15; higher scores indicating higher levels of death anxiety. Means usually range between 4.5 and

7.0 (Shell & Zinger, 1984). Several studies have found DAS to have acceptable reliability levels (Lucas, 1974). DAS is found to have a test-retest reliability correlation of .83, and internal consistency by Kuder Richardson reliability coefficient of .76. (White & Handal, 1991 Face validity and internal consistency found is claimed to be sufficient.

Temperament and Character Inventory (TCI; Cloninger, 2004)
The TCI is a self-report instrument measuring self-awareness. TCI measures four types of temperaments (novelty seeking, harm avoidance, reward dependence and persistence" and three character scales (self-directedness, cooperativeness and self-transcendence), According to Cloninger, an average temperament scores is often connected to an organized character and therefore most advantageous. A high character score indicates maturity, high self-awareness, and well-being (2004).

Validated to have global factorial congruence higher than .90 for all age groups, but unsatisfactory goodness-of-fit (Aluja et al., 2010). Revised versions were reliable in good-to-excellent range (Gutierrez-Zotes et al., 2015) – however not independently validated.

Inventory of Interpersonal Problems (IIP; Horowitz, 2008)
The IIP measures the following interpersonal difficulties: domineering/controlling, vindictive/self-centred, cold/distant, socially inhibited, non-assertive, overly accommodating, self-sacrificing, and intrusive/needy. The total score is found associated with levels of interpersonal mental distress (2008). Its properties is evaluated in both clinical and non-clincial samples, and have been considered to have acceptable reliability and validity.

Symptom Checklist Revised (SCL-90-R; Sereda, 2016).
The SCL-90-R assesses self-reported symptoms in the following scales: somatization, obsessive-compulsive, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism. In addition, the Global Severity Index assesses the overall psychological distress. The SCL-90 is validated to have satisfactory validity (Sereda et al., 2016).

Brief Symptom Inventory (BSI; Derogatis, 1993)
The BSI is a shorter version of the SCL-90-R that measures 53 Likert-type items measuring psychiatric and psychological tress. It involves the 9 primary dimensions: Somatization (SOM), ObsessiveCompulsive (O-C), Interpersonal Sensitivity (I-S), Depression (DEP), Anxiety (ANX), Hostility (HOS), Phobic Anxiety (PHOB), Paranoid Ideation (PAR) and Psychoticism (PSY). In addition, the scale provides three global indices of distress, which is called Global Severity Index (GSI), Positive Symptoms Distress Index (PSDI), and Positive Symptoms Total (PST). The BSI is proven to have high correlation with the SCL-90-R, with correlations ranging from .92 to .99. Derogatis (1993) found internal consistency reliability alpha for the nine dimensions are found to be robust, raning from .71 ot .85. T-test reliability is found to range from .68 to .91 (Derogatis, 1993)

Brief Persisting Effects Questionnaire (BPQQ; Griffiths et al., 2006).
The BPEQ is based on another questionnaire (Persisting Effect Questionnaire; PEQ) developed by Griffiths to collect information on changes in attitudes, moods, behaviour and spiritual experiences, in addition to personal meaning, personal wellbeing and life satisfaction (Griffiths, Richards, McCann and Jesse, 2006; Griffiths, Richards, Johnson and Jesse, 2008). The BPEQ includes only three of the question from PEQ;

(1) *How personally meaningful was the experience* (rated 1= no more than routine, everyday experiences; 2= similar to meaningful experiences that occur on average once or more a week; 3=similar to meaningful experiences that occur on average once a month; 4=similar to meaningful experiences that occur on average once a year; 5=similar to meaningful experiences that occur on average once every 5 years; 6=among the 10 most meaningful experiences of my life; 7=among the 5 most meaningful experiences of my life; and 8=the single most meaningful experience of my life)?
(**2**) *Indicate the degree to which the experience was spiritually significant to you* (rated 1=not at all, 2=slightly, 3=moderately, 4=very much, 5=among the 5 most spiritually significant experiences and 6=the single most spiritually significant experience of my life).
(3) *Do you believe that the experience and your contemplation of that experience have led to change in your current sense of personal well- being or life satisfaction* (rated +3=increased very much, +2=increased moderately, +1=increased slightly, 0=no change, −1=decreased slightly, −2=decreased moderately, and −3=decreased very much).
The BPEQ has no known validations. The PEQ are used in several studies of alterations of consciousness, none of which report psychometric information (Griffiths et al., 2016; Ross et al., 2016)). Griffiths (2016) notes that the PEQ is not independently validated.

Appendix 5: Details from quality assessment of papers on SBT

A) Zhang et al., 2017
Findings:
The aim of the study was to investigate the effect of slow breathing (stepwise from 14, 12.5, 11, 9.5, 8 and 7 breaths per minute) changes in CPC and pulse transit time (PTT; the time it takes for the pulse pressure waveform to propagate through a length of the arterial tree). There was a significant difference within subjects in both blood pressure and PTT between spontaneous breathing and slow breathing – blood pressure decreased and PTT increased. Phase and amplitude dynamics increased, with the highest level of coupling at 11 breaths per minute.
Strengths:
Rigorous description of scientific background and aims. States inclusion and exclusion criteria's. States ethics, clearly describes equipment. Interventions is clearly described, and procedural fidelity described. Analyses are described – t-test with mean, confidence intervals. Sequences are described for each phase. Identified sequence completed and drop-outs, and reasons. Data is reported for all outcomes. No adverse effects did occur. Interpretation and summations is done. Limitations are addressed. Applicability is stated. Funding is stated.
Limitations.
Does not report procedural changes, no planned replication, no blinding or randomization, limited information on demographic characteristics. Protocol not available. Only healthy – aging and disease not addressed. Short term effect. Not randomized rate. No assessment of emotion or subjective feelings of consciousness, more complex experiences.

Overall evaluation using "Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE; Tate et al., 2017):
= 17 of 26 points*

B) Dick et al., 2014

The aim was to examine respiratory frequency, heart rate, HRV, power spectral density of blood pressure and ventilatory pattern before, during and after a 20 minute session of slow breathing, the hypothesis being that slow breathing evoked short-term plasticity of cardiorespiratory coupling. There was great variability in the data. However, blood pressure decreased in all subjects, MAP decreased in nearly all, HR decreased in a few and increase in others. There was not sufficient evidence for drawing specific conclusions.

Strengths:

Research question, method and intervention rigours described. Physiological measurements reliable and validated, and descried in detail. Addresses limitations. Describes individual data. (Same as above).

Limitations.

Small sample. Refers only to individuals. Little description of significance levels before, during and after. No planned replication. No randomization or blinding. No stated descriptive test examining the demographic variability within the group, nor the HRV indices before breathing. Outcomes not described in table. No assessment of qualitative experiences, complex emotions or consciousness alteration.

Overall evaluation using "Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE; Tate et al., 2017):
= 18/26 potins

C) Fonoberova et al., 2014

Findings:

The aim of the study was to examine system-level cardiovascular changes during resonance breahting and the extend individuals differ in cardiovascular benefit. This was done using a computational physiology approach, by dynamically modelling the human cardiovascular system at rest compared to during resonance breathing. During session, Significant improvements in several of the modelled cardiovascular functions (blood flow to internal organs, sensitivity of the sympathetic component of the baroflex, ventricular elastance) were observed during slow breathing. Individual differences in the magnitude and nature of the responses suggest that that HRV biofeedback might need tailoring to individual patients.

Strengths:

Rigorous descriptions of background, aims and design. Selection criteria stated. Model used for computing physiological data validated, taking extensive amounts of parameters into account. Intervention and method clearly described.

Limitations.

No planned replication, randomization, or blinding. Lack of description of demographic data, no description of setting. Lack of description in raw data. Young and healthy participants makes it difficult to generalise. No measurement of qualitative experiences, emotions or consciousness.

Overall evaluation using "Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE; Tate et al., 2017):
= 14/26

D) Hinterberger et al., 2019

Findings:

The aim of the study was to investigate the link between body rhythms and slow cortical brains dynamics during breathing sessions from 6 to 14 cycles/min (each 7 minutes each). Measures of resouration, HRV and EEG, in addition to subjective ratings of ….. were recorded. Respiration cycle correlated with RSA

Respiratory cycle correlated with slow cortical potentials of EEG, with highest correlation at 10 breaths per minute. In other words, speed of breath had an impact on brain dynamics. The maximum of synchronization between respiration, SCP and RSA was also experienced as the most relaxing one (at 10 breaths per minutes). Ratet on a scale of naturalness, valence and arousal.

Strengths:

Descriptions of backgrounds, aims, intervention and design. Good description of equipment and measurements used. Analyses well described, involving confounding variables.

Limitations.

Little demographic information, no planned replication. No randomization or description of any procedural changes. No description of setting or context, nor missing data or protocol. The rating of subjective experience was not an validated instrument. Lacked measurements of complex emotions.

Overall evaluation using "Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE; Tate et al., 2017):

=15/26

E) Hsu et al., 2020

Findings:

As, brain rhythms as found to track respiratory inputs, The aim of the study was to examine if slow breathing would reorganize the relationship between brain waves and respiratory waves (by adjusting cortical phase to the slow train of respiratory inputs). During slow breathing, cortical phase activity was modulated relative to normal breathing. Specifically, activity in the alpha range spread across brain areas. At single-subject level, there was a unique and consistent phase adjustment to inspiratory input – adjusting for cardiac fluctuations and breathing-unrelated tasks. These organization of phase distribution did not occur during normal breathing. Phase coherence was reduced in temporal and frontal areas (consistent with other findings).

Strengths:

Rigorous descriptions of aims, background, design and intervention. Equipment and measurements described, in addition to calculations. Describes procedural changes.

Limitations.

Due to technical constrains, not all cardiorespiratory parameters were measured exhaustively. These should be better accounted for in future studies. Future studies should also address if normal breathing (not voluntary controlled normal breathing) has organizing function. No replication, randomisation, blinding, few participant characteristics, no setting, raw data, protocol. The rating of subjective experience was not an validated instrument. Lacked measurements of complex emotions.

Overall evaluation using “Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE; Tate et al., 2017):
=18/26

F) Xiao ma et al., 2017

Findings:

The aim of the study was to examine effect of 20 sessions of slow breathing on attention (NCT), affect (PANAS) and cortisol response to stress, compared to a control group. The slow breathing technique involved 15 minutes of normal breathing (average rate at 17 cycles/minute) followed by 15 minutes of slow, deep breathing (average rate of breath at 4 cycles/minutes). Instructors insured the slow breathing rate was below 6 breath/min). The outcomes were measured at baseline and after the 20 sessions. The intervention group also had a significant decrease in breathing frequency after the intervention. In addition, there was a significant group and time effect in breathing group on cortisol after training: breathing intervention group had significantly lower cortisol levels after training, while the control group did not. Long term: The lower frequency of respiration after intervention suggests an inculcated intervention, but this is not confirmed by further research.
In the breathing intervention group, there was a significant decrease in negative affect after the intervention. Further, there were significant increase in sustained attention after training, compared to baseline, in this group.

Strengths:

Control group existed. Gender balance was taken into consideration during the sampling procedure.). T-test were showed no between group differences in age, education or work experiences. There sessions were performed over a time period of 8 weeks, enabling assessments of long-term effects. There were both directly assessed outcomes-variables (cortisol levels and attention) and self-reported measurements (affect). Affect was measured by the PANAS scale (Watson et al., 1988), which has a high internal consistency, largely uncorrelated stable and reliable across cultures (Thompson, 2007). Statistical test for the main outcomes were 2 2 mixed repeated measures – between group factors were group and the within group factor were pre versus post test. P-values and confident values were reported properly. Low drop-out rate (2 of 40).

Limitations:

All participants were from the same, local IT company, somehow restricting the diversity of the sample. There were only one pre-test and one post-test. There were no reliability or validity report of the attention-instrument **(NCT).** No report of missing data. Though longer time follow-up than many other studies, no assessment of effects longer than 8 weeks. No assessment of emotion or subjective feelings of consciousness, more complex experiences.

Overall evaluation Based on Quality Assessment Tool for pre-post designs (Cummings et al., 2008):
0.68 potints of 1.0 (MEDIUM)

G) Lin et al., 2014

Findings:

The aim of the study was to examine the effect of a single session HRV-BF feedback compared to autogenic training on HRV indices, breathing rates and subjective relaxation scores. In the BRV.BF group the breathing rates were gradually decreased from 12, 8 to 6 breaths per minute. Outcomes was collected pre, during and after the session. During session,

Results indicated a significant increase in HRV indicted (specifically SDNN, LF, lnLF and LF/HF ratio) as well as decreased HT, lnHF and breathing rates during mid training, compared to pre- and post straining. This difference was more significant in the HRV-BF group than in the comparison group. HRV-BF also significantly increased subjective experience of relaxation, pre compared to post.

Strengths:

Scientific background, purpose and aims are well described. Participants in each group checked for between-group differences, and there are no significant differences in age, gender, anxiety, depression or HRV indicies. There are several tests, both before, during and after. Dependent variable is both directly measured and subjectively reported, before, during and after the procedure. The VAS is validated. ANOVA investigating two groups x three times interaction effects on HRV, breathing rates and subjective relaxation, adjusting for time. Sphericity was examined, Huynh-Feldt correction used is violated. If F was significant, Scheffes post hoc comparison conducted.

Limitations:

No description of missing data. No confidence intervals. No follow up over longer time. Both groups increased relaxation, and no third control group to rule out placebo. Only short term. No randomization. Though equal group design – some confounding could influence. No assessment of emotion or subjective feelings of consciousness, more complex experiences.

Overall evaluation Based on Quality Assessment Tool for pre-post designs (Cummings et al., 2008):

0.81 potints of 1.0

H) Sutarto et al., 2012

Findings:

The aim of the study was to examine the effect of five sessions HRV-BF training on stress and HRV indices, compared to a control group. Three was a special focus on the percentage of total power stems from LF activity. Each session involved 5-minute baseline recording, followed by 20 minutes HRV training. The biofeedback group also showed a significant increase in LF activity. Results showed a significant decrease in the depression, anxiety- and stress score (DASS) in the biofeedback group, while the control group did no report a significant effect.

Strengths:

Control group and random assignment. Long term – 5 weeks. Demographic variables described, and

T-test showed no significant difference between groups in age, years of working or education, nor anxiety, depression and stress. HRV indices also matched between groups at baseline. No protest difference in baseline scores of depression, anxiety or stress, nor in the frequency bandwidth (VLF, LF, HF) and BPM. Control group did all same procedures, even feedback display. But feedback was not informed by their HRV. Statistical measures compensation for violation of assumptions are explicitly names, namely the wolocon signed rank test for normality.

Limitations:

Homogenous sample (manufacturing operators). Only female. Small sample size. Unclear whether effects will sustain, increase or enlarge over time. No assessment of emotion or

subjective feelings of consciousness, more complex experiences.

Overall evaluation Based on Quality Assessment Tool for pre-post designs (Cummings et al., 2008): 0.75

I) Lehrer et al., 2003

Findings:

Heart rate variability biofeedback was examined as a method for increasing vagal baroreflex gain and improving pulmonary function through 10 sessions. Cognitive and physiological effects were measured in four sessions. Control group did only perform relaxation exercises, and no alteration of breathing rate. During breathing sessions, there were acute increases in LF and total spectrum heart rate variability, and in vagal baroreflex gain, correlated with slow breathing. Specifically, baroflex gain was significantly higher during the biofeedback periods than the rest periods. Total R-R interval spectral power, the LF spectral power for both BP and R-R interval was also greater during biofeedback . This did not occur in the control group. Across sessions, there was an increased resting baroflex gain, measured by increased pre-session resting baroreflex gain in the breathing group at the last session compared to the pre-session measurement at the first session. This did not occur in the control group. Peak expiratory flow did also increase between first and last session for the breathing group, and not in the control. Across sessions, subjects in the breahting group also reported fewer negative side effects of relaxation.

Strengths:

More heterogenous sample than other studies. Several tests (baseline and in 4 of 10 sessions) were taken. Participants were matched for age and gender. Outcomes were both measured directly by assessor (physiological data) and by self-report (relaxation scale and side effects scale). The instruments are validated.

Limitations:

Only short-time effects are examined. Lack of reporting of missing data.

No assessment of emotion or subjective feelings of consioussness, more complex experiences.

Overall evaluation Based on Quality Assessment Tool for pre-post designs (Cummings et al., 2008): 0.81

Appendix 6: Details in quality assessments of HB papers

A) Rock et al., 2015

Findings:

The aim was to measure the effect of HB on altered states of consciousness (ASA) and phenomenological subsystems using the Phenomenology of Consciousness Inventory (PCI; Pekala, 1991). ASA is one variable in the PCI. Further, translimiality was assessed by the Transliminality Scale Revised (Lange et al., 2000). A within-subject repeated measures (counterbalanced) design was used. The covariation matrices ("Psygrams") in PCI were significantly different ($p=0.003$) between the pre- and post-intervention in the HB group. The difference between the covariation matrices in the intervention group and the comparison group was not significant. Post hoc analyses showed that of the PCI dimensions, the HB group experiences significantly higher "Negative Affect" ($p<0.001$), "Altered Experience"

(altered experience of body, time and perception; p<0.000) and "Visual Imagery" (p<0.000) to both baseline and comparison group. The intervention group reported significantly higher scores of altered consciousness (p=0.002) than the comparison group, adjusting for baseline-scores. Baseline ASA accounted for 16% of the unique variability in post-test ASA score, making one`s phenomenology at baseline somehow influence of ones post-HB phenomenology.

Strengths:

Explicitly states that the original HB procedure by Grof is conducted. Addresses more complex experiences, such as altered consciousness. Protocol is described in detail. Further, the PCI is claimed to have respectable psychometric properties, as it is showed to reliably discriminate between different state, and having good internal consistency (Johanson, Valli, & Revonsuo, 2011,) The RTS was yielded a Cronbachs Aplha of .62 in the current study. Hypotheses are clearly stated, and the adhering statistical analysis rigorously described and justified.

Limitations:

Counterbalancing provides a comparison condition, but has several weaknesses in this design. The counterbalanced condition is exposed to many of the same stimuli as the intervention group – stimuli that are associated with conscious altering it themselves. This makes it difficult to interpret the results as there are no control group providing a reference point for a setting with no such stimuli. Further, there are no test comparing the breather- and sitter group, and therefore no information on whether they are comparable. It is little information on the sociodemographic properties of the participants, which makes it difficult to know how representative the sample is for the general population. No information on flow of patients.

Overall evaluation using "Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE; Tate et al., 2017):
= 16/26

B) Miller & Nielsen, 2015

Findings:

The aim of the study was to examine how self-awareness was influenced by four HB sessions (two weekend-workshops; 12 weeks between each). They assessed this outcome using the Temperament and Character Inventory (TCI-R), the Inventory of Interpersonal Problems (IIP) and Symptom Checklist (SCL-90). IIP assessed subject-object relations, SCL the object-object relations and TCI both set of relations. The outcomes were assessed both before the first session (pre-measurement), between the first and the second session (during-measurement), and after the last session (post-measurement). The outcomes were measured in three different groups; for the total group, for the novices only and for the experienced breathers only. For the total group, there were several significant findings. In the TCI-R, persistence was significantly increased bot pre-during (p=0.046) and pre-post (p=0.048). Cooperativeness decreased significantly from pre-test to during-test (p=0.036). For the SCL-90, paranoid ideation increased significantly both pre-during (p=0.021) and pre-post (p=0.021), all scores in normal range. Hostility decreased significantly between pre- and post test (0.0018). For the IIP, the total score decreased significantly between pre and post (p=0.044). Pre-post score of "overly accommodating" decreased significantly, as well as pre-post test of "intrusive/needy". The novices had the highest pre-scores in novelty seeking, reward dependence and persistence. They further had a significant decrease in both novelty seeking and persistence between pre-post test (0.02) –the post-test still being in the normal range. They further had a significant decrease in harm avoidance pre-during (p=0.02) and an

significant increase in persistence pre-post (0.02). They reported being significantly less social inhibited (p=0.04) between pre-and during, and had significantly higher paranoid ideation between pre-and post**.** For the experienced breathers, there was a increase in novelty seeking pre-during (p=0.026) and decrease in persistence (p=0.04). Self-transcendence increased from pre to post (p=0.02), as dominance decreased pre-post (0.04). Overly accommodating decreased from pre post (0.01), as well as needy and interpersonal sensitivity and hostility.

Strengths:

Examines more complex outcomes of the breathing technique, such as various forms of self-awareness). Follows the group over a longer period of time (30 weeks), which is the longest follow-up time of the included studies. There are both a pre-test, a during-test and a post-test. Instruments are validated in the literature, and several were chose to raise the construct validity. Richer data is further gathered by interviews, adding qualitative information to the outcomes. Design and aims stated clearly. Sociodemographic described. Measurements defined and clearly described. All participants completed the follow-up. Limitations, applicability and ethics stated.

Limitations:

No investigation of physiological outcomes. Small sample size, especially in the subgroups. The volunteers already had interest in HB, and are not necessarily representative for the norm. Threatens generalizability. Very short scientific background. No description of procedural changes, no planned replication and no randomization. No control groups. No descriptive tests for testing whether groups are similar. No protocol available. Only one pre-test, making it possible for expectations or timing to influence the measurements. No information on the background of the trainers. No detailed description of intervention, or any procedural changes during the interventions.

Overall evaluation using "Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE; Tate et al., 2017):
= 14/26 (MEDIUM)

C) Puente, 2014a

Findings:

The aim of the paper was to investigate the short-term, intermediate, and persistent effect of one HB session on distress, meaning of life, death anxiety and personal orientation in a young adult sample. Brief Symptoms Inventory (BSI; Derogatis, 1987) was used to assess symptoms of psychiatric and psychological distress, Personal state of orientation (POL; Shostrom, 1964) to assess changes in self-actualization, Brief Persisting effects Questionnaire (BPEQ; Griffiths et al., 2006) to asses how meaningful the experience was long-term, States of Consciousness (SCQ; Phanke, 1969) to assess alterations in consciousness, in addition to Death Anxiety Scale (DAS; Templer, 1970) and Purpose in Life (PIL; Crumbaugh & Maholick, 1969).
During: Six of the 29 subjects that filled out the form had a mystical experience according to the SCQ; three were novices and three where experienced breathers. High scores were found in "Ineffability", "Intuitive knowledge" and "Deeply felt positive mood". After one month: There were no significant changes in the BIS, DAS or PIL. IN the POL, there was a significant increase the subscale called "nature of Man" ($p<0.05$) – which measures degree of the constructive view of the nature of man, masculinity, and femininity.
After six months: There were no significant changes in the BIS, DAS or PIL. In the POL, "Time Competence", "Existentiality", "Nurture of Man", "Synergy" and "Acceptance of Aggression" was significantly increased ($p<0.05$). After twelve months: The only 12-month assessment was BPRQ, and 10 of the initial 30 participant filled out this form. This

assessment showed that two of the participants had “complete mystical experiences”. 5 of the 10 participants rated the HB session among the top five or top 10 most personally meaningful experiences in their life. Four rated the experience to increase their current sense of personal life satisfaction.
Strengths:
Scientific background and aims are well established. Design described. Interpretation, limitation, and applicability discussed. Long-term follow up of participants. Assesses a wide range of complex experiences and emotions. Several of the instruments used are validated.
Limitations:
No procedural changes described, no planned replication, no randomization and no blinding. Selection criteria not provided. Few demographics are given, only age and gender. Setting not provided, nor validity in all instruments. Analyses only briefly stated, and sequence completed for each participants not given. Raw data not given, nor statements of any adverse effects or protocol for the intervention. No control groups. Participants are recruited from the same workshops, which challenges generalizability. Follow-up was not complete, and there are no tests of whether the assessed participants are representative for the group. Intervention not described. Further, the setting for the different timepoint of assessment varied. This could have influenced results.

Overall evaluation using “Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE; Tate et al., 2017):
= 9/26 (LOW)

D) Puente, 2014b
Findings:
The aim of the study was to examine the subjective effects of one HB session in a daylong workshop, specifically the effects on consciousness and mystical experiences. The instrument assessing the effects of interest was the *States of Consciousness Questionnaire (SCQ; Stace, 1960; Phanke, Griffiths et al, 2006)* measured 1 to 5 hours after the HB. According to the SCQ cut-off (See theory section), 13 of the 134 participants had scores indicating a “Complete Mystical Experiences”. For the total group, the higher scores were in the subscales of “Deeply felt positive mood” (M= 0.57, SD = 0.26), “Transcendence of time and space” (M=0.43, SD=0.23) and “Internal unity” (M=0.43, SD=0.29). Eight of the 13 subjects (61.5%) having complete mystical experiences were first time breathers.
Strengths:
Rigorous scientific background, aims clearly stated. Refers to Grof Holotropic Breathwork. Operationalizes and assesses more complex experiences and emotion. Large sample.
Limitations:
No description of procedural changes. No planned replication and no randomizing or blinding. Setting or intervention not described in detail. Outcome measures described, but instrument not validated. No inferential statistics, as there are no pre-measurement performed. No reference of baseline state or experience. No protocol available for the intervention. Group collected by convenient sample, and from homogenous population. There is no pre-test, and no control group.

Overall evaluation using “Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE; Tate et al., 2017):
= 9/26 (LOW)

E) Somensula et al., 2017

Findings:
The authors examined the effects of a single session of HB on level of stress for nursing students. The breathing group (n=50) had significantly lower mean stress-scores in the post-test (24.6, SD=9.8), compared to the pre-test (32.4 (SD, 22.4). Significance levels not mentioned. Percentage of students with mild stress increased from 28% to 64%, moderate stress decreased from 52% to 28%, and the amount of severe stress reduced from 20% to 8%. There was not any significant change between pre-test and post-test scores in the control group (n=50).
Strengths:
The study has a large sample (100 students) which is positive in terms of statistical power. The relevance of the study is high, as solutions to stress in students are needed. In addition, literature on the effects of HB on stress lacking.
Limitations:
The abstract does not provide information on how the outcome is measured. The scientific background is limited and has no references. There are several sections missing in the paper. There is no probability sampling used, and no justifying of sample size for obtaining adequate power. There is no information on the HB procedure, or whether it follows the guidelines from Grof. Only one pre- and one post-test is performed, making regression to the mean a potential confounding variable. There is no sociodemographic data on either of the groups, and no descriptive statistics performed to compare the groups. This makes it difficult to know whether the effects are related to the HB session. There are no information on how stress is assessed, or whether validated instruments are used. There is little to no detailed information on the statistical tests, both in terms of descriptive and inferential analyses. No information on whether assumptions for the tests are met. P-values are not provided, neither are confidence intervals. No mention of missing data or flow of participants.

Overall evaluation using RISK OF BIAS for pre-post:
= 0.12 (POOR)

F) Denisa, 2003
Findings:
In the first section of the experiment, the authors examined differences in purpose in life Purpose In Life instrument (PIL; Crumbaugh and Maholock), attitudes and values (Value-Belief Q sort test; Fadiman & Mogar) and personal orientations (Personal Orientation Dimensions questionnaire; POI; Shostrom) before and after one session of HB (within subject).There was a significant increase from pre-score (M=113.1, SD=not provided) to post-score (M=117.1, SD=not provided) in the score of Purpose In Life (p=0.05) and a statistically significant reduction of “Rigidity and dogmatism” by 4 points (p=0.05). There were no significant changes in pre-and post-measures in the POI. In the second part, they compared subjects who had performed four sessions of HB and subjects who had not performed HB (between-subjects). In addition, the breathers gave a qualitative description of their experiences. The results of the Value Belief Q sort test showed that the breathing group had lower score in ”Rigdity and dogmatism” (p=0.001), lower “Profession of conventional values” (p=0.01), less “Scientific rigidity” (p=0.001), higher “Adequate approach to Reality” and higher score of “Psychedelic spectrum” (p=0.001). The POI questionnaire indicated that the subjects that had performed four HB sessions reported a higher score in “Existentialism” (p=0.01), higher “Emotional reactivity” (p=0.05), higher “Time Competence” (p=0.01), higher “Orientation of conduct” (p=0.05), higher “Spontaneity” (p=0.001), higher self-esteem (0.05) and higher “Intimate contact ability” (p=0.05), compared to the control group. The

qualitative testimonies of the breathers were predominated by eights themes; physical feelings, body motions, emotions, energy, insights, life of the experiencing individual, circumstances concerning birth, and crossing the limits to common reality.
Strengths:
Aims are stated in the introduction, as well as the relevance and need for the experiment. Though not described in detail, HB is referenced to Grof & Grof.
Participants in between-group design are stated as comparable in age, gender and education. Complex experiences and emotions are addressed, as well as effects such as quality of life, altered consciousness and existential aspects of the breathing session. Qualitative interviews are conducted, giving room for more rich data on outcomes. The PIL instrument is validated.
Limitations:
This could imply a restricted generalizability of the sample.
As to the Value-Belief Q sort test, it is Not possible to find the instrument itself nor validations of it. POI has no recent validation, and the existing from Silverstien and Fischer (1977) found poor internal consistency. Methodologically, there is somewhat limited scientific background and use of references in the introduction. The design is not stated nor described. The presentation of combined design is difficult to understand. No information on specific procedure of HB, or setting. No information on procedural changes. No information on sociodemographic data. Little information on the specific instruments used, their validation or details around the measurements. No description of terms used in outcome-measurements. Regarding limitations the within-subject section, there were only one pre- and post-test. The sample was small, and there was no data on participants displaying wheter they were representative for general population. Further, it was not exressed wheter all participants followed through, or how the instruments were assessed.
Regarding the between-group design, there were no data on differences between sociodemographic vairbales. Regarding the PIL, there are high pre-test scores in the first breathers' sample, while the control group have lower scores. The lack of descriptive analyses between baseline scores, makes it possible for existing differences to influence the findings.

Overall evaluation using "Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE; Tate et al., 2017):
= 4/26

Regarding limitations in the between-group design, the data and the descriptive statistics on sociodemopagric varbales are not provided. There is no probability sampling or randomization between groups, as the groups are chosen after the intervention is performed for the breathing group. No pre-test is conducted; one post-test for breathing group is compared to first test and only in control group. No justified sample size to obtain adequate power. Two of the three self-report instruments lacks proper validation in the litterature. There is little information on the statistical analyses, and no information on stastistical asusmptions necessary for the chosen tests. Correlations between outcomes are not examined, and there are no description of flow of patients or drop-out rate.

Overall evaluation using RISK OF BIAS for pre-post:
= 0.18 (POOR)

Supplementary Table 1: Risk of bias in within subject studies (Tate et al., 2017)

Single-Case Reporting Guideline In BEhavioural Interventions (SCRIBE) check-list	**Zhang et al., 2017**	**Dick et al., 2014**	**Fono-berova et al., 2014**	**Hinter-berger et al., 2019**	**Hsu et al., 2020**	**Rock et al. 2015**	**Puente, 2014a**	**Puente, 2014b**	**Miller & Nielsen, 2015**	**Denisa, 2003 (within subject-part)**
1 Title Identify the research as a single-case experimental design in the title	NO	NO	NO	NO	NO	No	NO	NO	NO	No
2 Abstract Summarize the research question, population, design, methods, including intervention/s (independent variable/s) and target, behavior/s and any other outcome/s (dependent variable/s), results, and conclusions	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
3 Scientific background Describe the scientific background to identify issue/s under analysis, current scientific knowledge, and gaps in that knowledge base	YES	YES	YES	YES	YES	YES	YES	YES	NO (very short)	NO
4 Aims State the purpose/aims of the study, research question/s, and, if applicable, hypotheses	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
5 Design Identify the design (e.g., withdrawal/reversal, multiple-baseline, alternating-treatments, changing-criterion, some combination thereof, or adaptive design) and describe the phases and	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO

phase sequence (whether determined a priori or data-driven) and, if applicable, criteria for phase change										
6 Procedural changes Describe any procedural changes that occurred during the course of the investigation after the start of the study	NO	YES	NO	NO	YES	NO	NO	NO	YES	NO
7 Replication Describe any planned replication	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
8 Randomization State whether randomization was used, and if so, describe the randomization method and the elements of the study that were randomized	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO
9 Blinding State whether blinding/masking was used, and if so, describe who was blinded/masked	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10 Selection criteria State the inclusion and exclusion criteria, if applicable, and the method of recruitment	YES	YES	YES	YES	YES	YES	NO	NO	YES	NO
11 Participant characteristics For each participant, describe the demographic characteristics and clinical (or other) features relevant to the research question, such that anonymity is ensured	NO	YES	NO	NO	NO	YES	YES	YES	YES	NO
12 Setting Describe characteristics of the setting and location	NO	NO	YES	NO	NO	YES	NO	NO	NO	NO

where the study was conducted										
13 Ethics State whether ethics approval was obtained and indicate if and how informed consent and/or assent were obtained	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
14 Measures Operationally define all target behaviors and outcome measures, describe reliability and validity, state how they were selected, and how and when they were measured	YES	YES	YES	YES	YES	YES	NO	NO	YES	NO
15 Equipment Clearly describe any equipment and/or materials (e.g., technological aids, biofeedback, computer programs, intervention manuals or other material resources) used to measure target behavior/s and other outcome/s or deliver the interventions	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO
16 Intervention Describe the intervention and control condition in each phase, including how and when they were actually administered, with as much detail as possible to facilitate attempts at replication	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO
17 Procedural fidelity Describe how procedural fidelity was evaluated in each phase	YES	YES	NO	NO	YES	NO	NO	NO	NO	NO

18 Analyses Describe and justify all methods used to analyse data	YES	YES	YES	YES	YES	YES	NO	NO	YES*	NO
19 Sequence completed For each participant, report the sequence actually completed, including the number of trials for each session for each case. For participant/s who did not complete, state when they stopped and the reasons	YES	YES	YES	NO	YES	NO	YES	YES	NO	NO
20 Outcomes and estimation For each participant, report results, including raw data, for each target behaviour and other outcome/s	NO	NO	NO	NO	NO	NO	YES	YES	NO	NO
21 Adverse events State whether or not any adverse events occurred for any participant and the phase in which they occurred	YES	YES	NO	YES	YES	NO	NO	NO	NO	NO
22 Interpretation Summarize findings and interpret the results in the context of current evidence	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
23 Limitations Discuss limitations, addressing sources of potential bias and imprecision	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
24 Applicability Discuss applicability and implications of the study findings	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
25 Protocol If available, state where a study protocol can be accessed	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
26 Funding Identify source/s of funding	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO

and other support; describe the role of funders										
	18/26	19/26	16/26	15/26	18/26	15/26	12/26	12/26	11/26	4/26

Supplementary Table 2: Risk of bias in pre-post studies (Cumings et al., 2008)

Quality Assessment Tool for pre-post designs	**Xiao Ma et al., 2017**	**Sutarto et al., 2012**	**Lin et al., 2014**	**Lehrer et al., 2003**	**Somensula et al., 2017**	**Denisa, 2003 (between-group)**
a. Was probability sampling used? (1)	0	0	0	0	0	0
b. Was sample size justified to obtain adequate power? (1)	0	0	0	0	0	0
Subtotal (n/2)	**0**	**0**	**0**	**0**	**0**	**0**
a. One pre-test or baseline and several post-test measures (2) or			2	2		
b. Simple before-and-after study (1)	1	1			1	0*
Subtotal (n/2)	**0.5**	**0.5**	1	**1**	**0.5**	**0**
Does the study employ a comparison strategy? An attempt to create or assess equivalence of groups at baseline by:						
a. Matching group participants (2) or	2	2	2	2		2
b. Statistical control (1) or					1	
c. None (0)						
Subtotal (n/2)	**1**	**1**	**1**	**1**	**0.5**	**1**
a. Was the DV directly measured by an assessor? (1)	1	1	1	1	0**	
b. Were dependent variables either						
i) Directly measured (2) or	2	2	2	2		
ii) Self-reported (1)	(1)	(1)	(1)			1
c. Were dependent variables measured reliably (with reliability indices previously or for this study)? (1)	1	1	1	1	0	0
d. Were dependent variables measured validly (with validity	1	1	1	1	0	0

assessments previously or for this study)? (1)						
Subtotal (n/5)	**1**	**1**	**1**	**1**	**0**	**0.2**
a. Was (were) the statistical test(s) used appropriate for the main outcome and at least 80% of the others? (1)	1	1	1	1	0	0
b. Were p values and confidence intervals reported properly? (1)	1	1	1	1	0	0
c. If multiple outcomes were studied, were correlations analysed? (1)	0	1	0	1	0	0
d. Were missing data managed appropriately? (1)	0	0	0	0	0	0
Subtotal (n/4)	**0.5**	**0.75**	**0.5**	**0.75**	**0**	**0**
a. Is attrition rate <30% (if no attrition code 1) (1)	1	1	1	1	0	0
Subtotal (n/1)	**1**	**1**	**1**	**1**	**0**	**0**
Total (n/16)	**0.68**	**0.75**	**0.81**	**0.81**	**0.12**	**0.18**
Overall Validity Rating	**Medium**	**High**	**High**	**High**	**Low**	**Low**

Note: * Only post-test. ** No information on assessment.

Supplementary Table 3: PRISMA check-list

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	p. 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	p. 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	p. 5,6,8,9
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	p. 5
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Table 1, p. 11
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	p. 9, 10
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	p. 10, 11
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	p. 12
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	p. 12
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Table 1., p.11
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Table 1., p.11
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	p. 12
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	-
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	p. 12
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	-
	13c	**Describe any methods used to tabulate or visually display results of individual studies and syntheses.**	-
	13d	**Describe any methods used to synthesize results and provide a rationale for the choice(s).** If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	-

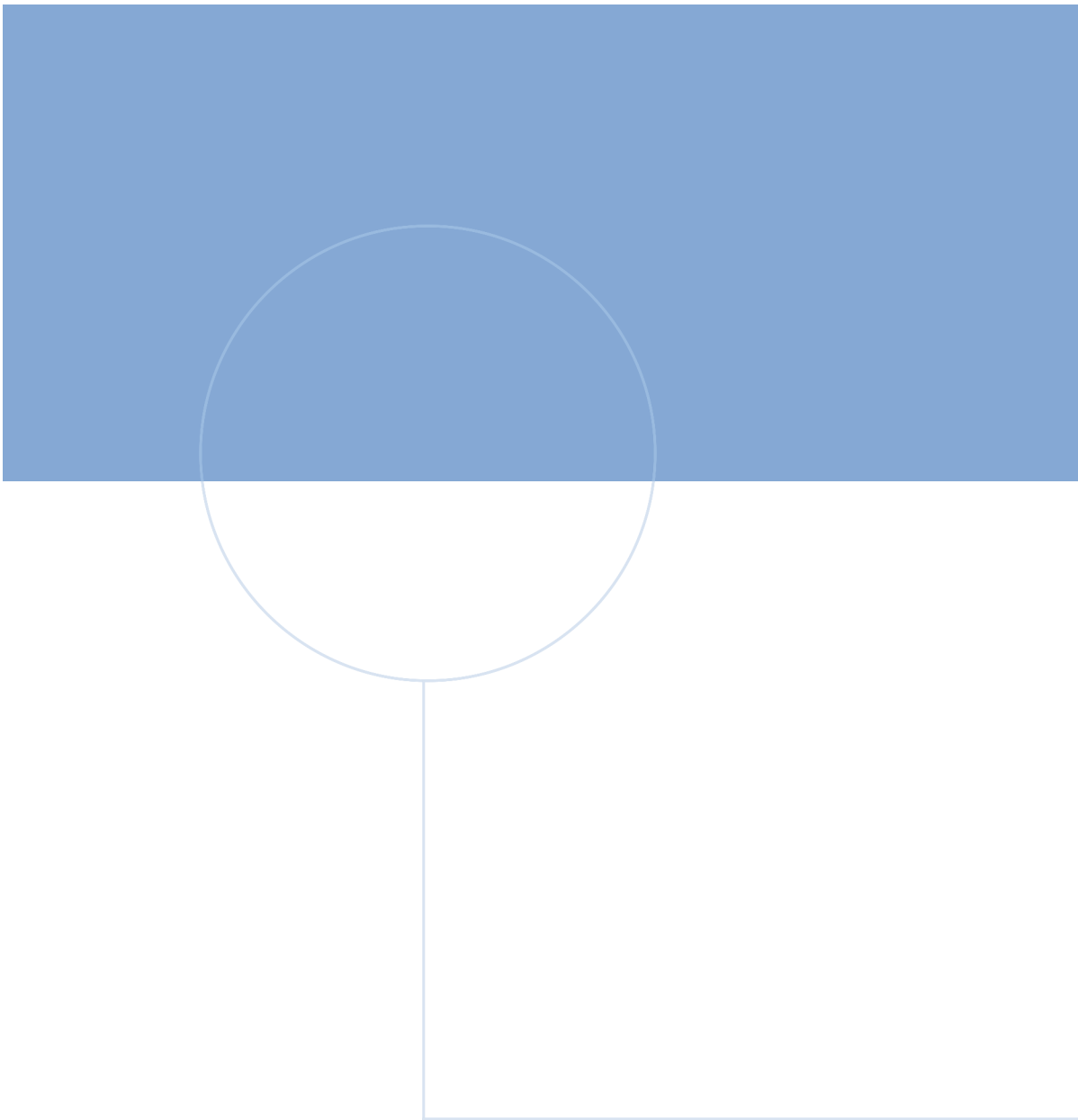
Section and Topic	Item #	Checklist item	Location where item is reported
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	-
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	-
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	p. 12
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	-
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Figure 1, p 13, Table 2, p. 13
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	p. 14
Study characteristics	17	Cite each included study and present its characteristics.	Table 3, p. 14
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	p. 20-24
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Table 3, p. 14
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	p. 14-20
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	-
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	-
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	-
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	p. 20-24
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	-
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	p. 24-32
	23b	Discuss any limitations of the evidence included in the review.	p. 25, 28
	23c	Discuss any limitations of the review processes used.	p. 33
	23d	Discuss implications of the results for practice, policy, and future research.	p. 28-33
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	-
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	-
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	-
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	-
Competing	26	Declare any competing interests of review authors.	-

Section and Topic	Item #	Checklist item	Location where item is reported
interests			
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	-

References:

(eget document)

Lin, I. M., Tai, L. Y., and Fan, S. Y. (2014). Breathing at a rate of 5.5 breaths per minute with equal inhalation-to-exhalation ratio increases heart rate variability. Int. J. Psychophysiol. 91, 206–211. doi: 10.1016/j.ijpsycho.2013.12.006



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