A Systematic Review of HeartMath© Interventions to Improve Psychological Outcomes in Individuals with Psychiatric Conditions

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Abstract: Background and objectives: A systematic review was undertaken to assess the effectiveness of HeartMath, heart rate variability biofeedback (HRVB) intervention studies within a variety of psychiatric conditions. **Design and methods:** Seven databases, including Web of Knowledge, Medline, Psych Info, Cinahl, Psych articles, Web of Science, the Cochrane Library and grey literature, were searched for suitable articles. Of the 1,701 citations identified, eight studies that utilised HeartMath HRVB interventions with psychiatric patients were included in the final analysis. A total of 64 patients aged 12-96 across a range of psychiatric conditions were examined in the systematic review. **Results** The review cautiously indicates that some groups of patients with psychiatric conditions report psychological improvement following HRVB HeartMath training. **Conclusions** These studies provide some evidence that HeartMath, HRVB interventions are promising in supporting beneficial outcomes for individuals with psychiatric conditions. The review points to future directions for HRVB interventions using the HeartMath technology.

Keywords: Coherence, HeartMath, heart rate variability, heart rhythms, psychiatric disorders.

Declarations

The main author completed this work as part of a Professional Doctorate in Health Psychology and no funding was obtained. The researcher is a qualified HeartMath coach but there were no conflicts of interest or competing benefits throughout any of the research.

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Introduction

The structure of the National Health System (NHS) mental health service in the UK is changing, pushed to capacity and under-resourced. The Global Mental Health Action Plan (2013-2020) has called for improved access to innovative and cost-effective interventions for treating psychiatric conditions (Avey et al., 2003; Lancet Global Mental Health Group, 2007; Saxena, Funk, & Chisholm, 2013).

Current interventions for treating psychiatric conditions are typically pharmacological including anxiolytics (e.g., pregabalin), anti-depressants (e.g., Selective serotonin reuptake inhibitors (SSRIs) and antipsychotics (e.g., olanzapine) which manage and reduce the intensity of symptoms (Predictable, 2006). Some of these medications aim to target and relax the nervous system (e.g., benzodiazepines), but due to some severe side effects and addictive properties, they are not advised long-term (Baldwin et al., 2013). Individuals can become reliant on these medications which can impact on their levels of self-esteem and self-efficacy which may lead to poorer health outcomes (Austin-Ketch et al., 2012; Zimmermann et al., 2012).

More recently, primary and secondary care providers are actively encouraged to promote an individual's control, choice and responsibility in managing their health (Leng, Baillie, & Raj, 2008). Hence, patient interest in alternative and complementary interventions has increased dramatically, one of which is Heart Rate Variability Biofeedback (HRVB) (for further information on other mind-body interventions, please refer to Park, 2013).

Heart Rate Variability (HRV) has been suggested to be an indicator of physiological stress and functioning of the nervous system and is measured by examining the beat-to-beat variation in the heart rhythm patterns (Edwards, 2020; McCraty, 2017). Research has revealed that low HRV levels are associated with psychopathological states such as anxiety (Thayer, Friedman, & Borkovec, 1996), depression (Beevers, Ellis, & Reid, 2011) and rumination (Brosschot, Van Dijk, & Thayer, 2007). In comparison, high HRV readings have been indicative of improved physical and mental health (Lehrer et al., 2006; Henriques et al., 2011; Ratanasiripong et al., 2015; Zucker et al., 2009; Kotozaki et al., 2014).

The use of HRVB interventions has expanded in popularity in more recent years for implementation in psychiatric conditions (Kapitza et al., 2010). Thus, interventions which target dysfunctional physiology from a 'bottom-up' perspective have demonstrated that patients are more able to identify and self-regulate their nervous systems, to calm challenging physical and mental symptoms, and increase physiological coherence (Leyro 2019; Pal Singh & Kaur, 2007; Kemp et al., 2012; McCraty et al., 2012). Coherence arises during positive emotional states when breath, heart and blood pressure become entrained. It is distinguished by a heart rhythm pattern of raised amplitude in low frequency heart rate variability of around 0.1 Hz, demonstrating synchronisation between the parasympathetic and sympathetic divisions of the autonomic nervous system (McCraty & Shaffer, 2015).

Due to the upsurge of interest in HRVB interventions and psychiatric conditions, there have been several reviews. Schoenberg & David (2014) examined 63 biofeedback intervention articles for use with psychiatric disorders. They revealed that 80.9% reported some clinical improvement, of which 65.0% were statistically significant ($p<.05$), concluding that biofeedback may be useful for psychiatric use. However, they examined a range of different biofeedback interventions (e.g. electroencephalography, electromyography, HRV and electrocardiography) and therefore, it is unclear if some types of biofeedback are more effective than others.

A recent meta-analysis also found a significant reduction in subjective reports of levels of anxiety and stress associated with HRV biofeedback training with substantial effect sizes evident in both within and between-group designs (Goessl, Curtiss, & Hofmann, 2017). The findings from the meta-analysis suggest that HRV-BF interventions are effective at reducing psychological measures of stress. However, the outcomes are sensitive to social desirability and methodological variance, therefore, there is a need to provide more objective measures such as physiological HRV improvements to validate the treatment effectiveness of biofeedback interventions (Van der swan et al., 2015).

Very recently, Poleszak et al. (2019) conducted a review examining the psychological and psychiatric benefits of biofeedback interventions in 23 articles. They concluded that HRVB is an effective therapy for use in depressive disorders, insomnia, ADHD and anxiety disorders. However, there was limited information available about the breakdown and quality of each study, research design and type of HRVB implemented. Therefore, drawing conclusions and evaluating the more detailed aspects of the systematic review is limited.

Collectively, these previous systematic reviews have demonstrated that HRVB interventions can be applicable in improving psychiatric outcomes; however, as already mentioned, there are different methods to measure HRV biofeedback. Of particular interest for this review is examining heart rate variability coherence as measured by HeartMath technology.

The Institute of HeartMath is non-profit organisation that has a mission and vision of promoting education, health, personal, social and global coherence research (Edwards, 2020). There have been no systematic reviews that have examined this type of HRVB only. HeartMath HRVB interventions employ a combination of psychological, physiological, behavioural and cognitive strategies to empower and educate individuals about the workings of their autonomic nervous system (Institute of HeartMath, 2014). Using technology such as the emWave®Pro Plus and the Inner Balance™, the individual receives immediate feedback via a sensor attached to the ear which displays their physiology via a visual format (e.g., on their mobile phone) and enables self-regulation in the moment initiated by changes in breathing or mood (Institute of HeartMath, 2014, Ratanasiripong et al., 2010).

This systematic review aims to build on, and advance knowledge of HRVB interventions using HeartMath technology and bring innovation and new direction into the psychiatric system.

Objectives

Review Questions

1. Are HeartMath interventions effective at improving psychological outcomes in patients with psychiatric conditions?

2. Do research studies report HRV coherence pre-post intervention?

Study Design

In order to gain clarity for the search terms, the acronym PICO was implemented for the review, see below for the breakdown (Higgins & Green, 2011).

PICO
Population: Psychiatric
Intervention: HeartMath HRVB
Control: Control, comparison or none

Outcomes

1. Change in psychiatric outcome measures.
2. To identify whether changes in HRV coherence values are reported

Methods

Protocol

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines (Liberati et al., 2009).

Eligibility Criteria

Following PICO, eligibility for inclusion in the systematic review consisted of any HeartMath intervention with individuals who have a psychiatric condition. All English language databases from years 1971- to present-day were searched that included published, unpublished and literature.

Inclusion Criteria

1. English published work
2. Any age from 12 years old
3. Psychiatric disorder
4. HeartMath HRVB intervention
5. HRV coherence as measured by a phonograph, ear or fingertip measurement

Exclusion

1. Any other HRV biofeedback measurement that is not HRV coherence as measured by HeartMath technology.

2. Any conditions which are known to affect cognitive abilities to some degree, e.g., dementia, autism and Asperger’s syndrome were excluded.

Information Sources

Seven different electronic databases including Web of Knowledge, Medline, Psych Info, Cinahl, Psych Articles, Web of Science, the Cochrane Library and grey literature were searched for English articles between the dates 01/08/19 and 12/02/20. A backward search was also completed by examining the suitable articles' reference list and further, recognised authors were contacted to gain access to potentially relevant articles for more information. These search strategies are in line with best practice to gain a robust search strategy for the systematic review (Forshaw, Tod & Eubank, 2018; Liberati et al., 2009).

Search

The following search terms were used for all databases:

"Heart rate variability biofeedback" OR "heart coherence" OR "Respiratory sinus arrhythmia" OR "HRV" OR "RSA" OR "resonance frequency biofeedback "AND anxiety OR "anorexia nervosa" OR "bipolar affective disorder" OR "depersonalisation disorder*" OR "personality disorder*" OR depression OR "eating disorder*" OR "bulimia nervosa" OR "binge eating disorder" OR "psych* disorder*" OR "psych* condition*" OR "obsessive-compulsive disorder*" OR "OCD" OR "MDD" OR "panic disorder*" OR "post-traumatic stress disorder*" OR "PTSD" OR "psychiatric disorder*" OR "psychological disorder*" OR "psychopathology" OR psychosis OR schizophrenia OR "borderline personality disorder*" OR addiction AND HeartMath Intervention*

Study Selection

The search strategy initially produced 1,701 articles, 304 of which were duplicates leaving 1,397 to be reviewed by title and abstract. 1,372 were excluded, the primary reason for exclusion was that HeartMath technology was not used in the study, leaving 25 full-text studies assessed for eligibility. Seventeen studies were excluded during data extraction as either the population group was not appropriate, or the study was not using a HeartMath protocol leaving a total of eight studies included in the review, see Figure 1 for the PRISMA flow diagram.

Eligibility for inclusion was rated by the first author and then moderated blindly by the second and third authors. Disagreements were negligible and were discussed leading to minor re-ratings due to emerging novel interpretations of the criteria in relation to the papers being considered. None of the small amendments led to a change in the inclusion/exclusion status of a paper.

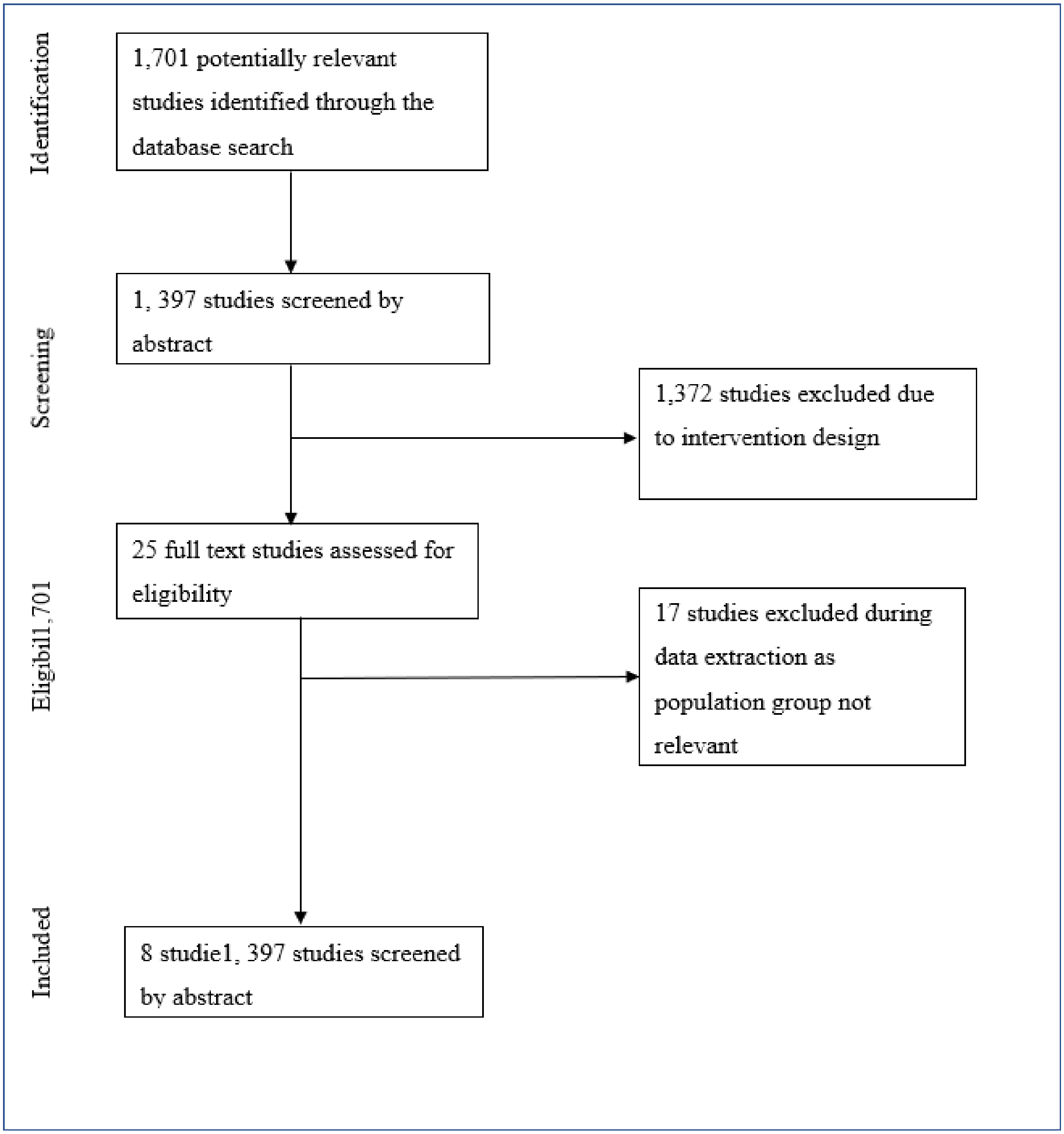

Figure 1: PRISMA flow diagram for study inclusion

Risk of Bias in Individual Studies

Quality and risk of bias in the studies were measured using The Effective Public Health Practice Project (EPHHP) tool, which was developed explicitly for use within public health professions and therefore, appropriate for this review. All of the studies were scored using a 'yes', no' or 'can't tell' response system for the six component ratings on *selection bias*, *study design*, *confounders*, *blinding*, *data collection measures*, *withdrawal and dropouts.* A global rating for each paper was then decided and classified as *strong* (if no weak ratings in any of the components), *moderate* (if there were one or more weak ratings) and *weak* (if there were two or more weak ratings). This tool has been used effectively in a substantial number of similar reviews (EPHPP, 1998).

Data Collection Process

A data extraction sheet was employed to record specific information on each study including; (1) first author and year of publication, (2) country, (3) characteristics of participants (category of the psychiatric condition, sample size and gender), (4) type of design, (5) intervention condition (including frequency and length of HRVB sessions), (5) primary outcome measures (psychological or psychiatric measures and physiological HRV coherence data if provided), (6) results following intervention (psychological and physiological if reported).

Results

Study Selection

Eight studies met all the inclusion criteria for the systematic review, see Table 1 for a detailed breakdown of the study characteristics, design and specific outcomes.

Characteristics of Included Studies

Countries

Out of the eight studies, five were published in the USA (Lande et al., 2010; Ginsberg, Berry, & Powell, 2010; Beckham, Greene, & Meltzer-Brody, 2013; Reyes, 2014; Jester, Rozek, & McKelley, 2019), the remaining in different countries including France (Trousselard et al., 2016), Netherlands (Hartogs, Bartels-Velthuis, Van der Ploeg, & Bos, 2017) and Canada (McAusland, & Addington, 2018).

Study design

Amongst the eight included studies, the methodological study design varied. The most common research design was a within group with five studies employing this approach (Beckham, Greene, & Meltzer-Brody, 2013; Reyes, 2014; Trousselard et al., 2016; McAusland, & Addington, 2018; Jester, Rozek, & McKelley, 2019). There were two quasi-experimental designs (Ginsberg, Berry, & Powell, 2010; Lande et al., 2010) **and** one cohort study (Hartogs, Bartels-Velthuis, Van der Ploeg, & Bos, 2017).

Of the eight studies, five were pilot studies (McAusland, & Addington, 2018; Trousselard et al., 2016; Beckham, Greene, & Meltzer-Brody, 2013; Lande et al., 2010; Ginsberg, Berry, & Powell, 2010)

Participant Characteristics

Sixty-four psychiatric patients in total were recruited across the eight reviewed studies, age range 12-96 years old. Three studies included patients with PTSD (Ginsberg, Berry, & Powell, 2010; Lande et al., 2010; Reyes, 2014) and three different studies included patients with a range of psychiatric conditions (Beckham, Greene, & Meltzer-Brody, 2013; McAusland, & Addington, 2018; Jester, Rozek, & McKelley, 2019). The remaining studies included specific psychiatric conditions; schizophrenia (Trousselard et al., 2016) and major depression (Hartogs, Bartels-Velthuis, Van der Ploeg, & Bos, 2017).

Sample Sizes

There was a range of sample sizes in the research design ranging from the highest, 38 participants (Lande, 2010) to the least which was seven (Hartogs, Bartels-Velthuis, Van der Ploeg, & Bos, 2017).

Three of the studies contained 100% male patients (Ginsberg, Berry, & Powell, 2010; Lande et al., 2010; Reyes, 2014), one study used 100% female patients (Beckham, Greene, & Meltzer-Brody, 2013) and the rest were mixed-gender (Trousselard et al., 2016; Hartogs, Bartels-Velthuis, Van der Ploeg, & Bos, 2017; McAusland, & Addington, 2018; Jester, Rozek, & McKelley, 2019).

Intervention

The intervention lengths and training protocols varied in each research design. As displayed in Table 1, the number of intervention minutes that participants completed with a researcher/psychologist or biofeedback therapist ranged from 20 minutes (McAusland, & Addington, 2018) to the highest training of HRVB up to 720 minutes (Trousselard et al., 2016). The number of sessions ranged from one (McAusland, & Addington, 2018) to the most, 12 sessions (Trousselard et al., 2016) with the majority ranging between 6-12 sessions (Lande et al., 2010; Reyes, 2014; Jester, Rozek, & McKelley, 2019; Hartogs, Bartels-Velthuis, Van der Ploeg, & Bos, 2017).

Outcome Measures

Across the eight selected papers, studies varied greatly regarding the measures used as there was a range of different psychiatric conditions. The outcome measure used included; The PTSD Checklist (PCL) (Ventureyra et al., 2002), State-Trait Anxiety Inventory for Adults (STAI-AD) (Spielberger, 1983), Beck Depression Inventory-II (BDI) (Beck, Steer, & Brown, 1996), Scale of Prodromal Symptoms (SOPS) (McGlashan et al., 2001), Kessler Psychological Distress Scale (K10) (Kessler et al., 2002), Information Processing test battery (ATTN/IM) (Vasterling et al., 2002), Zung Self- Rating Anxiety Scale (SAS) (Zung, 1971), Zung Self-Rating Depression Scale (SDS) (Zung, 1965), the Positive Outcome list (POL) (Appelo, 2005), Spielberger State-Trait Anxiety (STAI) (Spielberger et al., 1983), Warwick Edinburgh Mental Well-Being Scale (WEMWBS) (Tennant et al., 2007), Linear Analog Self-Assessment (LASA) (Locke et al., 2007), The Positive And Negative Syndrome Scale (PANSS) (Guelfi, 1997; Kay et al., 1987), Freibury Mindfulness Inventory-14 (FMI) (Walach et al., 2006), Trail Making Test – Part A (TMT-A) (Reitan, 1995) and The Derogatis Stress Profile (DSP) (Derogatis, 1987).

Effectiveness of HRVB interventions

Primary Outcome

The primary outcomes of the systematic review were to examine the psychological benefits of HRVB on individuals with psychiatric conditions. Overall, of the eight studies, seven reported some level of psychological benefit following the intervention; more details per psychiatric condition are reviewed herewith.

For individuals with PTSD the findings were mixed; the study by Reyes (2014) found significant reductions in PTSD severity ($p<.001$) in contrast to Lande et al. (2010) who found no significant differences in levels of PTSD symptoms (as measured by PCL) or depression (as measured by SDS) post-intervention. A critical methodological difference exists between these studies; for the Lande et al. (2010) study, participants received a maximum of 120 minutes of HRVB training. However, the session protocol is not clear, compared to that of Reyes (2014) who completed the sessions over eight weeks and asked individuals to engage in daily practice. The third study with a PTSD population by Ginsberg, Berry, & Powell, (2010) did find significant improvements in the information processing (ATTN/IM) markers $p<.05$, but they did not include post measures on PTSD symptoms; therefore, it is hard to remark on PTSD symptomatology.

Three different studies recruited patients with a range of psychiatric conditions which examined collectively reveal some psychological improvements following HRVB but will be discussed separately in more detail. Beckham, Greene, & Meltzer-Brody (2013) recruited female patients who were suffering from severe perinatal anxiety and depression and found significant reductions on levels of anxiety (STAI), improvements in mental wellbeing (WEMWBS) and quality of life (LASA) ($p<0.05$) following the HRVB intervention. The study by McAusland, & Addington (2018) recruited patients with anxiety and who were high risk for psychosis, and results were a little less clear. They found clinically significant psychological reductions but only in some aspects of dysphoric mood and stress responses (as measures by SOPS) $p<.01$ but not for anxiety (SAS) or distress (K10). However, the individuals in this study only received 20 minutes of HRVB with a researcher and instead completed the rest of the training alone at home. The most recent study by Jester, Rozek, & McKelley (2019) recruited older adults with a range of psychiatric conditions and found clinically significant reductions in depression (BDI) $p<.001$ and anxiety (STAI-AD) $p<.05$. There was also a significant increase in attentional skills as measured by the TMT-A ($p=.001$), which is strong evidence for the effectiveness of HRVB interventions on psychiatric symptomology.

The remaining two studies were focused on one psychiatric condition only. The study by Hartogs, Bartels-Velthuis, Van der Ploeg & Bos (2017) recruited patients with major depression and reported that 71% of patients reported a reduction in depression levels. However, no value of statistical significance or valid psychometric measures were employed and findings were based on a single item. The final study by Trousselard et al. (2016) recruited schizophrenic patients and following an HRVB intervention found significant improvements in anxiety (STAI) and mindfulness (FMI) ($p<.05$). However, no significant differences in all other measures of stress and wellbeing were found (as measured by PANSS, WEMWBS and DSP).

Secondary Outcome

The secondary outcome of the review was to examine if HRV coherence levels were reported. Out of the eight studies, only one study provided statistical analysis of HRV coherence; Ginsberg, Berry, & Powell (2010) found HRV coherence was achieved by all participants with PTSD post-HRVB training which was significant at the <5% level**.**

Two studies reported an improvement of HRV coherence levels following the intervention but did not conduct an in-depth statistical analysis (Reyes, 2014; Beckham, Greene, & Meltzer-Brody, 2013). Further, five studies did not refer to HRV coherence as an outcome measure at all (Lande et al., 2010; McAusland, & Addington, 2018; Jester, Rozek, & McKelley, 2019; Trousselard et al., 2016; Hartogs, Bartels-Velthuis, Van der Ploeg, & Bos, 2017).

Risk of Bias

The EPHHP risk of bias measure emphasized several weaknesses within some of the review papers. The main weakness was in study design and blinding which is expected due to five out of the eight studies being pilot studies (McAusland, & Addington, 2018; Trousselard et al., 2016; Beckham, Greene, & Meltzer-Brody, 2013; Lande et al., 2010; Ginsberg, Berry, & Powell, 2010). Regarding selection bias, all studies were classified as *medium* or *strong* as they were likely to be somewhat representative of the target population. Six of the eight studies were rated moderate for *data collection measures* as most of the tools were reliable and valid.

Overall, seven out of the eight studies were given a global rating of ‘weak’ mainly due to research design. The most common research approach involved a within-groups design with five studies employing this approach (Beckham, Greene, & Meltzer-Brody, 2013; Reyes, 2014; Trousselard et al., 2016; McAusland, & Addington, 2018; Jester, Rozek, & McKelley, 2019). There were two quasi-experimental designs (Ginsberg, Berry, & Powell, 2010; Lande et al., 2010) and one cohort study **(**Hartogs, Bartels-Velthuis, Van der Ploeg, & Bos, 2017) which are often subject to reliability and validity issues. However, all eight selected studies in this review demonstrated clear aims and research questions, utilised appropriate population groups, and had moderate levels of data collection and minimum attrition rate, (see Table 2 for more information).

Table 1. Study characteristics

Study (first author, year)	Country	a) Population b) Sample size c) % female	Type of design	Intervention condition(s) Number of sessions	Control conditions (s)	Primary Measures a) Psychological b) Physiological (HRV coherence)	Outcome a) Psychological b) Physiological (HRV coherence)
Ginsberg (2010)	USA	a) PTSD b) 10 (5 in the treatment group, 5 in the compare group) c) 0%	Pilot Quasi-experiment	HeartMath 1 x 4 weekly sessions (not stated how many minutes)	Usual care	a) ATTN/IM b) emWave®Pro Plus hardware and Stress reliever for home use	a) Significant improvements in the information processing (ATTN/IM) markers p<.05 b) HRV coherence was achieved by all participants post HRVB training significant at p<.05 level
Lande (2010)	USA	a) PTSD b) 39 (22 in the intervention group, 17 in control group) c) 13.6% in research group, 17.6% in control group	Pilot Quasi-experiment	HeartMath six sessions in total 2 x 20-minute sessions over three weeks (120 mins in total)	Usual care	a) SDS, PCL b) HeartMath, freeze frame fingertip pulse	a) No significant differences in levels of depression (SDS) or PTSD symptoms (PCL) post intervention b) No statistics calculated
Beckham (2013)	USA	a) Severe perinatal depression and anxiety b) 15 c) 100%	Pilot Within design	HeartMath HRV-BF 2 sessions in total ranging from 30-60 mins (120 minutes max 1-1 sessions)	none	a) STAI, WEMWBS, LASA b) HeartMath emWave software infrared ear-clip	a) Significant reductions on levels of anxiety (STAI), improvements in mental wellbeing (WEMWBS) and quality of life (LASA) p <0.001. b) Improvements HRV coherence scores; however, no statistical analyses were conducted.

Study (first author, year)	**Country**	**a) Population b) Sample size c) % female**	**Type of design**	**Intervention condition(s) Number of sessions**	**Control conditions (s)**	**Primary Measures a) Psychological b) Physiological (HRV coherence)**	**Outcome a) Psychological b) Physiological (HRV coherence)**
Reyes (2014)	California	a) PTSD b) 27 c) 0%	Within design 8 weeks	HeartMath HRV-BF 8 x once weekly Asked to do daily practice group sessions	none	a) PCL b) HeartMath emWave Pro software infrared ear-clip	a) Significant reductions in PTSD severity (PCL) p <.001 b) Average group HRV coherence increased after the 8-week group series
Trousselard (2016)	France	a) Schizophrenia b)10 c) 50%	Pilot HeartMath Within design	12 x weekly 1 hour Over 2 Months (up to 720 minutes) and home practice	none	a) STAI, PANSS, FMI, WEMWBS, DSP b) HeartMath infrared ear-clip	a) Significant improvement in anxiety (STAI) and mindfulness (FMI), p<.05. No significant differences in all other measures PANSS, WEMWBS, DSP. b) No statistics calculated
Hartogs (2017)	The Netherlan ds	a) Major depression b) 7 c) 90%	HeartMath Cohort study	3-8 weekly sessions 45-60-minute session (Max 480 minutes)	none	a) BDI, VAS, POL b) HeartMath emWave infrared ear-clip	a) 5/7 patients reported a reduction in depression levels, but no value of statistical significance was given. b) No statistics calculated

Study (first author, year)	Country	a) Population b) Sample size c) % female	Type of design	Intervention condition(s) Number of sessions	Control conditions (s)	Primary Measures a) Psychological b) Physiological (HRV coherence)	Outcome a) Psychological b) Physiological (HRV coherence)
McAusland (2018)	Canada	a) Anxiety and clinical high risk for Psychosis b) 20 c) 70%	Within design 4 weeks	Pilot HeartMath 20 minutes with researcher home practice for one hour per week over 4 weeks (max240 minutes)	none	a) SOPS, SAS, K10 b) HeartMath, emWave 2 infrared ear-clip	a) Clinically significant reductions only found in dysphoric mood and stress responses as measures by SOPS p <.01. No change for K10, SAS b) No information reported
Jester (2019)	USA	a) Older adults with psychiatric diagnosis either anxiety, depression or bipolar b) 20 c) 70%	Within design 3 weeks	HeartMath HRV-BF intervention Six 30- min sessions (max 180 minutes)	none	a) STAI-AD, BDI, TMT-A, Stroop b) HeartMath emWave Pro software an infrared ear-clip	a) Clinically significant reductions were found in depression (BDI) p <.001 and anxiety (STAI-AD) p<.05. A significant increase in attentional skills as measured by the TMT-A was found p = .001. No differences in Stroop task. b) No information reported

The PTSD Checklist (PCL), State-Trait Anxiety Inventory for Adults (STAI-AD), Beck Depression Inventory-II (BDI), Scale of Prodromal Symptoms (SOPS), Kessler Psychological Distress Scale (K10), Zung Self- Rating Anxiety Scale (SAS), Zung Self-Rating Depression Scale (SDS), the Positive Outcome list (POL), Information Processing test battery (ATTN/IM), Spielberger State-Trait Anxiety (STAI), Warwick Edinburgh Mental Well-Being Scale (WEMWBS), Linear Analog Self-Assessment (LASA), The Positive And Negative Syndrome Scale (PANSS), Freibury Mindfulness Inventory-14 (FMI), The Derogatis Stress Profile (DSP), Trail Making Test – Part A (TMT-A)

Table 2. Assessment of risk of bias using the EPHHP

Study (first author, year)	Selection bias	Study design	Confounders	Blinding	Data Collection measures	Withdrawal & dropouts	Global rating for paper
Ginsberg (2010)	MODERATE	WEAK	MODERATE	WEAK	WEAK	MODERATE	WEAK
Lande (2010)	MODERATE	STRONG	MODERATE	WEAK	MODERATE	MODERATE	MODERATE
Beckham (2013)	STRONG	WEAK	WEAK	WEAK	STRONG	MODERATE	WEAK
Reyes (2014)	STRONG	WEAK	WEAK	WEAK	MODERATE	MODERATE	WEAK
Trousselard (2016)	MODERATE	WEAK	WEAK	WEAK	MODERATE	MODERATE	WEAK
Hartogs (2017)	MODERATE	WEAK	WEAK	WEAK	MODERATE	MODERATE	WEAK
McAusland (2018)	MODERATE	WEAK	WEAK	WEAK	MODERATE	WEAK	WEAK
Jester (2019)	MODERATE	WEAK	WEAK	WEAK	MODERATE	WEAK	WEAK

Discussion

This systematic review examined the effectiveness of HeartMath interventions on psychological and physiological outcomes in individuals with psychiatric conditions. Previous reviews have identified the effectiveness of HRVB interventions within various psychiatric conditions (Schoenberg & David, 2014; Poleszak et al., 2019; Goessl et al., 2017). A systematic review by Schoenberg & David (2014) analysed 63 biofeedback intervention articles for use with various psychiatric disorders and found that 80.9% reported some clinical improvement, of which 65.0% were statistically significant (p<.05). The articles examined in the review included a range of biofeedback interventions (including electrocardiography, electroencephalography, electromyography and HRV) and therefore, it was undistinguishable if certain types of biofeedback are more effective than others.

A further meta-analysis by Goessl, Curtiss, & Hofmann (2017) reported significant reductions in subjective reports of levels of stress and anxiety associated with HRV biofeedback training. In addition, substantial effect sizes were evident in both between and within group designs with the authors concluding that HRV-BF interventions are effective at reducing psychological measures of stress. More recently, Poleszak et al. (2019) conducted a review examining the psychological and psychiatric benefits of biofeedback interventions in 23 articles. They concluded that HRVB is a successful therapy for use in anxiety disorders, insomnia, ADHD and depressive disorders.

Collectively, these previous systematic reviews have demonstrated that HRVB interventions can be applicable in improving psychiatric outcomes as a whole. The systematic review presented in this paper extends these findings of previous reviews and demonstrates that some groups of patients with psychiatric conditions report psychological improvement following HRVB HeartMath training. More specifically, HeartMath interventions appear to beneficial for a range of conditions including, PTDS, anxiety, stress, depression, and schizophrenia in a wide age range. More poignantly, Ginsberg, Berry & Powell (2010) report that the results from their pilot study for individuals with PTSD are promising in that although sample sizes were small, the effect size was large enough to produce statistical significance for some of the observed outcomes. In fact, they indicate that the statistically significant improvement in HRVB outcome measures is comparable to effect sizes produced by standard treatments for PTSD. This is in line with the study by Jester (2019), who also reports that HeartMath interventions were a significant predictor of changes in psychiatric symptoms and cognition and revealed large effect size decreases in depression, state anxiety, and trait anxiety.

In contrast, some of the studies reviewed do not show improvement in psychiatric outcomes following HeartMath interventions; one of the reasons for the discrepancy may be methodological. The length of the training protocol and the amount of personal practice in HRVB interventions could be one factor influencing clinical outcomes; for example, the study with the longest standardized training time was 720 min by Trousselard et al. (2016) compared to 20 minutes in the study by McAusland & Addington (2018). As discussed in the review by Schoenberg & David (2014), the HRVB literature lacks standardization, and although templates and protocols do exist (e.g., Lehrer et al., 2013), not all studies follow the guidelines or report HRV data. Further, a problem with the studies used in this review, and other HRVB studies generally, is that there is often no randomization or controlling for medication which has been found to affect HRV levels (Leyro, 2019).

The broader findings of HRVB interventions have been found to improve levels of HRV in respect of many physical health problems such as heart disease, hypertension, emphysema, insomnia, asthma, fibromyalgia, back pain and chronic fatigue (Paine et al., 2009; Lehrer et al., 2006; Hassett et al., 2007; Windhurst et al., 2017). Considerable improvements are also reported in objective health-related measures following HRVB training such as improved ANS function and balance (Tiller et al., 1996), and the cortisol/DHEA ratio (McCraty et al., 1998), immune system function (McCraty et al., 1996) and improved glycaemic regulation and cholesterol levels (McCraty, Atkinson, Lipsenthal, et al., 2003).

HRVB interventions may be effective to use alongside additional medical care and other psychological interventions such as CBT and therefore treat aim to treat mind-body health (Rusch et al., 2011). Practically, HRV biofeedback is comparatively easy to use, learn and teach. It is low cost and, the Inner Balance™ app recently developed by HeartMath can be used on smartphones, further reducing implementation barriers as it can be used in and out of the research and/or clinical setting. This type of stress management intervention may be effective in preventing high attrition due to being non-invasive, non-threatening and very person-centered (Van der Zwan et al., 2015).

Limitations

A criticism of this review is that five out of the eight studies were pilot studies, and further, seven out of the eight studies were classified as ‘weak’ concerning the risk of bias following assessment with the EPHPP scale. However, with the rise of interest in HRVB interventions, conducting preliminary analyses with pilot studies before proceeding to more costly and time-consuming interventions is not only essential but cost-effective. Some of the studies used in this review have highlighted that it is not always logistically feasible to conduct RCTs in inpatient or outpatient settings due to sampling size, duration of hospital stays, and acuity of illness (Eliopoulos et al., 2004). Although some of the studies are rated as weak they are endorsed as being suitable for review as the majority of the studies are pragmatic and realistic, for example that of Beckham, Greene & Meltzer-Brody (2013) who conducted their research in hospital settings with patients with severe psychiatric conditions which by the very nature of the design brings ecological validity to the research. However, without control groups, it is difficult to say with certainty that the improvements in psychological outcome measures are attributable to the usage of HRVB rather than regression to the mean, effects of time, social desirability and therapist bias.

All the eight studies endorsed the premise that HRVB is an alternative, non-pharmacologic, safe, therapeutic intervention ideal for patients who are more vulnerable or at risk of pharmaceutical complications. For example, the study by Beckham, Greene, & Meltzer-Brody (2013) recognized the use of HeartMath technology and the HRVB intervention for use with anxiety and depression given the increased fear about harmful side effects of pharmacologic treatments on a developing foetus. As recommended by Leyro (2019), HRVB interventions have strong potential that endorses future research and clinical dissemination.

Implications

With the structure of the NHS changing, it being seen as over-burdened, under resourced and pushed to capacity, there is a drive for individuals to improve their self-management and accordingly, primary care providers could actively promote self-regulation skills and include a system wide initiative to be proactive and promote individual wellness (Lemaire et al., 2011).

It is clear that coherence can affect our physiological, emotional, mental and physical health and these benefits extend further to improved cognitive functioning and enhanced optimal performance, perceptual processing and intentional behaviour (McCraty, Atkinson, Tomasino, & Bradley, 2009).

Future Directions

A significant finding in this review is to provide more structure and direction to future HRV coherence research using HeartMath technology. Designs should follow guidelines concerning psychophysiological research for use in experiment planning, data analysis and data reporting (Laborde et al., 2017; McCraty et al., 2015). The guidelines highlight the importance of using an instrument specific to measure physiological changes in HRV. The latest HeartMath technology, emWavePro Plus is a valid and reliable measurement tool to identify changes in HRV coherence pre-post intervention (Institute of HeartMath, 2014). The benefit of using the emWave®Pro Plus HeartMath technology is that detailed analysis of additional components in HRV, for example, low, very low and high-frequency measures are available (Institute of HeartMath, 2014). Furthermore, the utilisation of emWave®Pro Plus technology is specifically for healthcare professionals and is an easy way to inexpensively add standardized HRV coherence measures and assessment for research and clinical practice. Such assessments are available for use in a wide range of applications. These include quantifying HRV levels in relation to autonomic nervous system activity as well as identifying changes in HRV or coherence levels, and documenting any physiological baseline shifting over time (Institute of HeartMath, 2014). The review highlights the lack of HRV coherence data reported from researchers using the HeartMath technology and encourages a standardised format that would include three HRV coherence measures pre- and post-intervention. These include; resting HRV assessment (minimum five minutes) in which an individual is asked to sit quietly without talking; this provides a baseline HRV. The second assessment is the ‘stress preparation’, participants are invited to sit for three minutes as if they were preparing emotionally for an important upcoming event or activity and to focus their attention in the centre of their chest and experience a positive feeling such as care or appreciation for someone or some special place. The final assessment consists of a one-minute deep breathing assessment where the participant is encouraged to breathe as deeply and comfortably at the pace shown on a computer screen. By utilising this protocol, as recommended by McCraty, Atkinson, & Dispenza (2018), researchers could generate HRV coherence data that could be reviewed more accurately within and between research studies.

Conclusions

Overall, this systematic review provides reasonable evidence that HeartMath, HRVB interventions are promising for use in psychiatric conditions. Further randomised controlled trials are needed since the available evidence is notably lacking in these despite their gold standard status.

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