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The effects of HeartMath Heart Lock-In on elementary students' HRV and self-reported emotion regulation skills

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Abstract

It is important to address social and emotional concerns early on, as they can adversely affect learning at all levels. The classroom is an ideal context for fostering healthy social and emotional development. For example, emotion regulation can be reinforced through simple daily practices within schools. The current applied research project was in collaboration with multiple community partners and assessed the effectiveness of a classroom-based Heart-Math practice (Heart Lock-In) on resting heart rate variability (HRV) and self-reported emotional benefits in elementary students. This repeated-measures study was conducted in central Alberta, Canada, in 2020 and involved obtaining pre–post HRV measurements from $N = 24$ grade five students who participated in a teacher-led 5-min Heart Lock-In (like loving-kindness—radiating love to oneself and others) daily for 4 weeks. We hypothesized that the practice would increase resting HRV compared to a 4-week relaxation control. Qualitative questions were included to capture perceptions of the utility and impact of the practice. Univariate analysis of variance revealed that the HeartMath intervention significantly increased HRV compared to the relaxation control. Students reported enhanced emotional stability, feeling more positive about themselves, and improved interpersonal relationships. They expressed that the practice gives them better focus, which

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helps us to improve their performance (e.g., in academics and athletics). These findings provide evidence that a simple and short HeartMath ER practice can be practical for school educators, administrators, and counselors to implement in the classroom.

KEYWORDS
emotion regulation, Heart Lock-In, HeartMath, heart rate variability

1 | INTRODUCTION

Previous research emphasizes the importance of addressing social and emotional concerns early, as they may interfere with children's learning and hinder academic performance (Zins et al., 2007). Children are suffering from elevated levels of anxiety and stress (c.f. Aranberri-Ruiz et al., 2022). Cartwright-Hatton et al. (2006) conducted a review that yielded rates of anxiety diagnosis in children ranging from 2.6% to 41.2% globally; anxiety disorders are the most common psychological challenge in children and adolescence. They assert that this is concerning, given that treatment options are limited for this age group (Cartwright-Hatton et al., 2006). Early prevention efforts are essential; thus, a shift is occurring in both research and practice toward a curriculum that encourages healthy social and emotional development. Because children spend so much of their time in schools, the classroom environment has been emphasized as an important context in which to foster healthy social and emotional development (Jones & Bouffard, 2012). Furthermore, Zins et al. (2004) present compelling evidence in their book "Building academic success on social and emotional learning: What does the research say?" suggesting that the integration of social-emotional learning (SEL) in schools is essential for academic success. Researchers tend to agree that early school efforts to develop socioemotional skills, such as emotion regulation (ER) are beneficial in fostering increased academic success (e.g., Sheikhbardsiri et al., 2020; Zins et al., 2007). Jones and Bouffard (2012) assert that schools and classrooms are an important context for fostering the social and emotional development of children. They emphasize the value of teaching skills, such as managing negative emotions, remaining calm and focused, and managing relationships with peers and adults (Jones & Bouffard, 2012).

Dusenbury and Weissberg (2017) argue that for children to succeed in school and life, they need to develop adequate social, emotional, and academic competencies. These authors define SEL as policies, programs, and practices that build children's ability to understand and manage their emotions, to feel and show empathy for others, to form and sustain positive relationships, and to set and achieve positive personal goals (Dusenbury & Weissberg, 2017). Many schools and teachers are incorporating SEL programs in elementary and secondary schools (Jones & Bouffard, 2012). Jones and Bouffard (2012) advocate for schools to focus on incorporating SEL skills into their daily interactions with students through practices that are low-cost, time-efficient, and integrated easily within the curriculum. They highlight the need for more specific strategies in addition to, or instead of, a comprehensive SEL program. Durlak et al. (2011) conducted a meta-analysis and found the most effective SEL initiatives were those that encompassed four main elements referred to as SAFE: (1) sequenced activities connected to skills, (2) active learning, (3) focus on developing at least one skill, and (4) explicitly targeting specific skills. An example of this could be an ER practice guided by teachers that allow student participation.

McRae and Gross (2020) define ER as efforts to impact one's own emotions as well as the emotions of others. Gross (2015b) describes a process model of ER in which one first identifies a need for emotional regulation, then selects and implements an ER strategy, and finally, monitors and tracks one's progress and/or success. McRae and

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Gross (2020) assert that ER interventions for children tend to focus on educating teachers about emotional intelligence (a much broader concept that includes ER) and providing techniques for children to practice within the school environment (e.g., Hoffmann et al., 2020).

Hoffmann and associates (2020) assert ER skills are critical to academic achievement and should be taught through daily routines and practices within schools. During childhood, emotional intensity and reactivity are heightened, and ER is underdeveloped; thus, this is an ideal time to instill effective strategies (c.f. Aranberri-Ruiz et al., 2022). Skills that enhance heart rate variability (HRV) are a promising direction, as higher HRV contributes to the healthy functioning of self-regulatory capability and psychophysiological resilience (McCraty, 2022; McCraty et al., 2006). HRV is a measure of the variance in time intervals between each heartbeat (McCraty, 2015, 2022). Low HRV reflects reduced variation in the time interval between each consecutive heartbeat, suggesting desynchronization of the autonomic nervous system (ANS) (Bradley et al., 2010; McCraty et al., 2006; McLeod & Boyes, 2021). High HRV (larger variance between heartbeats) reflects synchronization or balance (Bradley et al., 2010; McCraty et al., 2006; McLeod & Boyes, 2021). Higher levels of HRV contribute to the healthy functioning of self-regulatory capability and resilience (McCraty, 2022). Practices that impact HRV are a promising avenue to enhance social-emotional learning and ER.

1.1 | HeartMath Institute, positive emotions, and ER

HeartMath Institute builds emotional resilience through simple practices designed to induce positive emotions to enhance HRV, often using their *Inner Balance* app or *emWave* biofeedback software (McCraty et al., 1998, 2006; McCraty & Shaffer, 2015). HeartMath skills have been researched in a variety of applied contexts (e.g., schools, military, police, first responders, and medical professionals; McCraty, 2022; Sheikhbardsiri et al., 2019). Edwards (2020) argues that HeartMath is promising as it is founded on diverse and rigorous scientific research, with Google Scholar citations exceeding 8000 and over 400 publications supporting its validity and impact.

HeartMath practices involve heart-focused breathing, experiencing renewing feelings, and radiating care to oneself and others (the combination of these techniques is known as the Heart Lock-In method; HeartMath Institute, 2014; McCraty et al., 1998). According to the HeartMath system, *renewing emotions* (e.g., care, appreciation, compassion) are those that produce a sense of coherence or balance in the ANS, higher HRV, and have been found to have positive effects on health such as decreased cortisol levels (e.g., Elbers & McCraty, 2020; HeartMath Institute, 2014; McCraty, 2022; McCraty et al., 1998; Rein et al., 1995). *Depleting emotions* (e.g., anger, frustration, anxiety), on the other hand, have been associated with incoherence or imbalance in the ANS, lower HRV, as well as higher signs of stress such as elevated cortisol (e.g., Elbers & McCraty, 2020; HeartMath Institute, 2014; McCraty, 2022; McCraty et al., 1998; Rein et al., 1995).

Researchers have found various benefits to self-inducing positive emotions through similar practices to HeartMath, such as loving-kindness meditation (LKM) (e.g., Fredrickson et al., 2008; Kok et al., 2013). According to Fredrickson's (2001), broadening and building theory experiencing frequent positive emotions promotes an upward spiral of increasing cognitive flexibility, behavioral opportunities, and resources, such as social connections and health. Although negative emotions are normal and have an adaptive purpose (e.g., for survival; Tooby & Cosmides, 1990), experiencing frequent negative emotions (especially in the absence of positive emotions) can have detrimental effects on well-being (e.g., Fredrickson et al., 2008; McCraty et al., 1998; McCraty & Zayas, 2014). Research suggests that experiencing positive emotions more frequently has long-term adaptive benefits such as being more resistant to colds, having fewer headaches, less chest pain, and having a lower likelihood of cardiovascular disease (Boehm & Kubzansky, 2012; Cohen et al., 2006; Fredrickson et al., 2008).

LKM directs individuals to produce self-generated positive emotions while meditating by sending love and compassion to themselves and others (Fredrickson et al., 2008). LKM starts with sending well-wishes to oneself and gradually expands the circle of compassion outward to include loved ones, acquaintances, strangers, and eventually

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all living beings. Fredrickson et al. (2008) found that individuals practicing LKM experienced increased positive emotions daily, which in turn, increased their sense of purpose in life and perceived social support while decreasing symptoms of illness. Fredrickson (2001) asserts that positive emotions are crucial to building personal resilience as they enhance coping and meaning in the face of adversity. Eliciting positive emotions may play an essential role in physical and psychosocial well-being through enhanced vagal tone and social connectedness (Kok & Fredrickson, 2010; Kok et al., 2013). Self-inducing positive emotions increase HRV and emotional stability, which protect mechanisms against unhealthy emotional and behavioral patterns (McCraty & Shaffer, 2015; McCraty & Zayas, 2014).

The process model of emotion regulation (PMER) contends that emotional experience ultimately results from a dynamic interplay between one's emotional reaction and ER (Aranberri-Ruiz et al., 2022; Gross, 2015a). While the emotional reaction tends to be automatic and physiological (e.g., involving the vagus nerve, ANS, and HRV), ER is often conscious and intentional with efforts made to adjust emotional experience (Aranberri-Ruiz et al., 2022). HeartMath practices regulate emotional experience (subjectively and physiologically) and produce an emotionally, mentally, and physiologically balanced or coherent state (McCraty, 2015). McCraty (2022) recently reviewed a large body of research demonstrating the connections between self-induced positive emotions, stronger HRV patterns, greater psychophysiological coherence, and enhanced psychosocial well-being.

1.2 | Coherence, HRV, and biofeedback

Heart coherence or cardiac coherence is a physiological measure used by HeartMath to define the harmonious synchronicity of the heart–brain connection. This coherence can be "measured by heart rate variability (HRV) analysis, wherein a person's heart rhythm pattern becomes more ordered" (McCraty, 2015, p. 26). Research has illustrated that emotions impact heart-brain communication, which can be measured by HRV (McCraty, 2015, 2022). Research suggests that vagus nerve stimulation underlies the effectiveness of practices that regulate HRV (Christodoulou et al., 2020).

Polyvagal theory (Porges, 1995) holds that emotional reactions are physiologically activated automatically by the vagus nerve via heart rate changes based on perceived risk to an organism. A parasympathetic reaction occurs when safety is perceived, whereas a sympathetic reaction occurs in response to perceptions that safety is at risk (c.f. Aranberri-Ruiz et al., 2022). The ANS, and particularly the vagus nerve, is essential to the development of emotional experience as well as the ability to self-regulate emotions and social behavior (McCraty, 2015). The vagus nerve influences conditions such as mood and anxiety disorders, immune response, digestion issues, and cardiac regulation (Breit et al., 2018). Research indicates that breathing techniques impact the vagus nerve and are associated with regulating the stress response (Breit et al., 2018). For example, practicing mindfulness produces positive benefits on health by stimulating the vagus nerve, as respiratory vagal nerve stimulation reduces heart rate (Rod, 2015).

HRV is one of the most effective ways to monitor the functioning of the ANS (McCraty & Shaffer, 2015; McCraty, 2022). It is a noninvasive, indirect measure of the balance between the sympathetic (fight or flight) and parasympathetic (rest and digest) branches of the ANS (Christodoulou et al., 2020; McCraty, 2015). It has been a valuable tool in studying emotions physiologically and provides a more in-depth understanding of emotions in psychopathological processes (Appelhans & Luecken, 2006; McCraty, 2022; McCraty et al., 2003; McCraty & Shaffer, 2015). Low HRV is demonstrated with a reduced variation in the time interval between each consecutive heartbeat, suggesting desynchronization of the nervous system (incoherence). Incoherence is illustrated as uneven and jagged peaks and is accompanied by the color red when using the HeartMath biofeedback sensor and their Inner Balance app or emWave software (Bradley et al., 2010; McCraty et al., 2006; McLeod & Boyes, 2021). Low HRV strongly predicts a wide range of mental and physical pathologies (Rovere et al., 1998). Specifically, it can lead to fibromyalgia, sleep disorders, asthma, irritable bowel syndrome, anxiety, insulin resistance, increased

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inflammation, and increased risk of heart failure (Gorman & Sloan, 2000; Jarczok et al., 2014; Lutfi, 2012; Mazurak et al., 2012; Meeus et al., 2013; Sessa et al., 2018; Stein et al., 2008).

High HRV is represented visually by balanced waves on the biofeedback along with the color green; this is referred to as coherence and reflects the synchronization of the two branches of the ANS (Bradley et al., 2010; McCraty et al., 2006; McLeod & Boyes, 2021). Research findings suggest that higher HRV contributes to the healthy functioning of self-regulatory capability and resilience (McCraty, 2015, 2022). Therefore, techniques that increase HRV improve self-regulation and resilience, while simultaneously decreasing the development and progression of mental and physical health challenges. Using physiological measures (such as HeartMath biofeedback) allows children and teachers to have immediate visual feedback on the effectiveness of ER practices and a tangible way to track improvements over time, thus reinforcing skills learned (Christodoulou et al., 2020; McCraty & Shaffer, 2015).

Heart Rate Variability Coherence Biofeedback (HRVCB) training consists of a combination of ER training accompanied by HRV technology with the goal of enhancing coherence in nervous system activity (May et al., 2019). Researchers have successfully incorporated HRVCB into schools, and the results thus far have been promising, suggesting that HRVCB improves academic performance, emotional stability, and HRV (e.g., Bradley et al., 2010; May et al., 2019; McLeod & Boyes, 2021).

1.3 | HRVCB and ER in schools

Some have applied HRVCB training within college, university, and high school student samples. For example, May et al. (2019) implemented a 4-week ER and biofeedback program with college students and found that the training reduced school burnout while increasing academic performance. Similarly, Qahar Sarwari and Nubil Wahab (2018) found HeartMath practices (e.g., Quick Coherence) to be effective in positively impacting the HRV patterns of university students. Shahirah Sha'ari and Amin (2020) also found that using HeartMath HRV biofeedback increased the resilience of university students. McLeod and Boyes (2021) implemented a HeartMath technique (heart-focused breathing) along with the HeartMath biofeedback in adolescence (high school) for 50 min twice a week and found increases in test-related self-efficacy, academic achievement, positive affect, and decreased worry about social stressors. Although these studies suggest HeartMath training is effective for college, university, and high school students, fewer studies exist on applying HeartMath practices and biofeedback within younger populations, such as elementary school students.

McCraty et al. (1998) assessed an emotion self-management program consisting of two techniques, the Cut-True and the Heart Lock-In, in which the experimental group generated a positive emotion and maintained a positive state. The experimental group would practice the combination of the techniques for 30 min, five times a week, for 4 weeks. The self-management program effectively reduced stress, specifically decreasing cortisol and negative affect, while increasing dehydroepiandrosterone (DHEA) hormones, positive affect, and coherence in HRV (McCraty et al., 1998). Such improvements in ER have implications for enhancing academic motivation and success in children (Graziano et al., 2007).

A national study on Test Edge (the basis of HeartMath Institute's Smart Brain Wise Heart Program) revealed that self-induced coherence reduced test anxiety, improved test scores, enhanced social relations, and increased class enjoyment (Bradley et al., 2007; McCraty, 2015). Another Test Edge study with grade 10 students found that HeartMath skills combined with biofeedback increased HRV, decreased test anxiety, and enhanced academic performance (Bradley et al., 2010). Bothe et al. (2014) implemented an elementary school-based stress management technique consisting of a three-step process: deep breathing, movement, and guided imagery. The technique revealed significant improvements in anxiety symptoms immediately following 4 months of practicing 10 min of the intervention and was maintained at the 1-year follow-up (Bothe et al., 2014). Immediate postintervention HRV measurements utilizing the Freeze-Framer (now emWave PC), a heart rhythm coherence

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biofeedback system, revealed improvements. At the 1-year follow-up, there was a sustained significant improvement compared to the control group (Bothe et al., 2014). Qualitative results indicated that the intervention was helpful for children during stressful periods at school and home (Bothe et al., 2014). Similarly, a recent study by Aranberri-Ruiz et al. (2022) found that a breath-focused HRV HeartMath biofeedback intervention reduced anxiety and social stress in primary school students.

Evidence to date suggests that ER techniques aimed at increasing HRV are efficacious in providing immediate and long-term benefits. HeartMath practices are ideal for teachers to incorporate as they have been demonstrated to be effective, they are simple and accessible to anyone, and they can be practiced within a short period of time.

1.4 | The current study

As mentioned, research has indicated that practicing HeartMath ER techniques can lead to improvements in children's HRV, ER, and academic success (e.g., Aranberri-Ruiz et al., 2022; Bothe et al., 2014; Bradley et al., 2007, 2010; McCraty, 2015; McCraty et al., 2006; McLeod & Boyes, 2021). However, HeartMath and HRV research with younger children is relatively new, and additional research is required. For example, literature is scarce regarding the specific duration of HeartMath practice, and the length of time practicing. Further research is needed to investigate whether a shorter duration of practice can significantly impact HRV. A short practice each day (say 5 min instead of the more typical 30–50 min) would be ideal for school-aged children, as this would be more realistic for those working with children to incorporate into the day.

Previous studies have focused mainly on heart-focused breathing or Quick Coherence; however, HeartMath Institute claims that their Heart Lock-In technique is the most powerful for establishing a coherent baseline or resting HRV pattern (HeartMath Institute, 2014). Therefore, the purpose of this study was to evaluate the Heart Lock-In practice to determine if the technique has a meaningful impact on elementary students' resting HRV. The Heart Lock-In method is comprised of three stages. First, participants focus their attention on the area of the heart and direct their breath in and out of the heart center while slowing down and deepening their breathing (heart-focused breathing; HeartMath Institute, 2014). Next, participants activate and sustain a renewing feeling of their choosing, such as care, love, gratitude, or compassion (Quick Coherence Technique; HeartMath Institute, 2014). In the final stage, the students sustain and radiate that renewing feeling(s) to themselves and extend it outwards to others (Heart Lock-In HeartMath Institute, 2014).

We predicted that practicing the Heart Lock-in method for 5 min a day for 4 weeks would increase coherence in resting HRV measures and enhance self-reported ER skills in elementary students (compared to a 4-week relaxation control). Previous studies have yielded promising qualitative results suggesting HeartMath is helpful for children to use during stressful periods at school and home (e.g., Bothe et al., 2014). Therefore, open-ended feedback was also sought to assess the extent to which children found HeartMath to be beneficial and whether they employed HeartMath techniques in various contexts.

2 | METHODS

2.1 | Participants

Grade five students (N = 24, all 10–11 years old) completed three data collection sessions in Winter 2020. Although the total number of students in both classes who volunteered to participate was initially 40, the data of 16 participants were excluded due to attrition (data collection was during extreme winter weather conditions and the Covid-19 pandemic). Only those who attended all three data collection days were included, yielding a total sample of 24 participants (16 girls and 8 boys). The study was restricted to students in two classes whose teachers had

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volunteered to participate. The sample had little racial diversity, as most students identified as white. This is, however, representative of demographics within the region (Central Alberta, Canada).

A Community Liaison Worker, in collaboration with teachers, helped to secure participants. Recruitment was from two grade five classrooms from the same elementary school. Inclusion criteria were that participants needed to be present for all 3 data collection days and be in the classes who elected to participate. The study employed a repeated measures (within-subject) design to ensure all students would receive the potential benefits of the HeartMath intervention. Parents provided consent, and student participants gave verbal assent.

2.2 | Materials

The 4-week intervention consisted of the Heart Lock-In method (explained previously), which was led by the teachers trained in the HeartMath Resilience Advantage program by two certified HeartMath trainers (HeartMath Institute, 2014). The Heart Lock-In method was practiced collectively for 5 min every school day for 4 weeks. The research team provided each of the two classrooms with HeartMath equipment, including 5 iPods per class (10 in total) with the Inner Balance app (HeartMath Institute, 2017) and the HeartMath biofeedback ear lobe sensors (HeartMath Institute, 2020). The iPods were rotated daily through each classroom, giving students an equal opportunity to witness changes in HRV as they practiced. It provides a total HRV of 100 points visually distributed by bars between low (red/incoherent), medium (blue), or high (green/coherent) HRV, as well as a coherence score, with higher scores reflecting greater (and healthier) HRV (Aranberri-Ruiz et al., 2022). Although this HRV biofeedback was used during practice with students, it was not collecting data on HRV throughout practice time. Within the current study, the measure of interest was changes created in resting HRV over a period of consistent practice. Although the biofeedback does provide immediate information about real-time changes in HRV during practice to students and teachers, we intended to capture 5 min of resting HRV not during the HeartMath practice itself.

HeartMath emWave Pro Plus biofeedback software (HeartMath Institute, 2022) obtained resting HRV measures at each of the three testing sessions, which involved a 5-min HRV recording per child transmitted through a sensor placed on the earlobe. The software has been used reliably in studies assessing the impacts of HeartMath practices on HRV (e.g., Aranberri-Ruiz et al., 2022; McCraty & Shaffer, 2015; Qahar Sarwari & Nubil Wahab, 2018; Shahirah Sha'ari & Amin, 2020). HRV is recorded using a time-domain measure known as the root mean squares of successive difference (RMSSD), and the metric is computed in milliseconds, a widely used measure of HRV (Berntson et al., 2016, p. 196). The RMSDD metric “is derived as the square root of the mean of the squared successive beat-to-beat heart period, [and] is based on the difference between the adjacent heart periods” (Berntson et al., 2016, p. 196). Higher HRV is indicated visually as more coherent balanced waves, whereas lower HRV is represented by incoherent erratic waves (Bradley et al., 2010; McLeod & Boyes, 2021; McCraty et al., 2006). One 5-min HRV measure was taken per student at each testing period because we were examining resting HRV (not HRV during practice time which was tracked during their practice for their own feedback in real time). Another reason for the single measure of HRV at each session was feasibility; it took nearly 3 h of class time to take each student aside for HRV recordings (measures were taken on two devices equipped with emWave Pro Plus). The emWave Pro Plus software is used by researchers to examine HRV in more detail. HRV information provided in real time by the Inner Balance biofeedback app during practice is considered sufficient in practical contexts (e.g., therapists, teachers, and children).

Participants also completed a brief online self-report survey through Simple Survey via a link using the school's Chromebooks. The survey included HeartMath-specific Likert-scale questions (see Table 1) and open-ended questions (see Table 2) created to obtain students' experiences with practicing HeartMath. Ivey (2012) argues that open-ended questions can be tailored for participants to express their perceptions and feelings more freely, which allows researchers to better capture participant experiences within real-life contexts. Ivey (2012) also asserts that

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TABLE 1 Means and standard deviations for Likert-scale items.

Likert question	Mean	Standard deviation
How often did you practice HeartMath outside of class?	2.00	0.71
How much did you enjoy practicing HeartMath?	3.92	1.02
How likely are you to show HeartMath to your family and friends?	2.67	1.13
How likely are you to continue practicing HeartMath at school?	3.21	1.14
How likely are you to continue practicing HeartMath at home?	3.33	1.27
How frequently you plan to practice HeartMath?	3.08	1.06
How effective was practicing HeartMath for helping with your feelings?	3.88	1.04

Note: Items are on a Likert scale ranging from 1 to 5 with higher numbers indicating a greater extent.

TABLE 2 Open-ended questions for qualitative data on experiences with HeartMath.

Open-ended survey questions
How has practicing HeartMath made you feel about yourself and others?
How has practicing HeartMath helped you to handle your feelings?
In what ways have you felt different after practicing HeartMath for 4 weeks?
Can you describe a time where you used HeartMath in your life to make you feel better?
How has HeartMath helped you during the school day?
If you have practiced HeartMath outside of class time, in what way, when, and where?
Please share if there are any other benefits that you experienced from practicing HeartMath?

qualitative methods generate useful information for improving various health practices within specific populations as this type of research preserves the context for the data within real-life settings. Finally, students answered demographic questions and whether they had engaged in physical activity before the assessments (to control for the impact of exercise on resting HRV at each of the three testing periods).

2.3 | Procedure

The study employed a repeated measures (within-subject) design to ensure all students would receive the potential benefits of the HeartMath intervention. The evaluation included three classroom visits/testing sessions. The first session was for obtaining baseline HRV assessments. The second visit was after 4 weeks of 5 min a day of relaxation to gain postrelaxation control HRV. The third session was after 4 weeks of 5 min a day of Heart Lock-In practice to record post-HeartMath intervention HRV. Each classroom visit lasted approximately 3 h.

Following the initial baseline classroom visit, participants engaged in the relaxation control group for the next 4 weeks. During this period, teachers dedicated 5 min of daily class time after lunch for students to engage in coloring activities. A relaxation control evaluation occurred after 4 weeks. Next, students practiced the Heart Lock-In method collectively for 5 min every school day for 4 consecutive weeks. The length of time for practice and time of day was chosen in collaboration with teachers to accommodate what is realistic for conducting activities with elementary students.

Heart Lock-In is said to be beneficial for establishing a new baseline or resting HRV (HeartMath Institute, 2014; McCraty, 2015). Participants practiced the Heart Lock-In method for 4 weeks, after which researchers took final post-HeartMath intervention measures. Mixed methods were used (quantitative and qualitative data). Qualitative data was included as it often generates more focused and in-depth information regarding the research topic than quantitative measures (Ivey, 2012; Kamberelis et al., 2013). SPSS statistical software was used for the quantitative data, and thematic analysis was conducted on the qualitative data. After the analyses were complete, the research team shared results with teachers and both classes of student participants. At the end of the study, students were verbally debriefed in depth.

3 | RESULTS

We used the time domain measure of RMSSD to compute HRV, expressed in a metric of milliseconds. There were no reliable differences between the HRV measurements across all three sessions, $F(2, 44) = 2.808$, $p = .071$. However, it is common to baseline correct HRV measurements to accurately assess physiological HRV, correcting for individual differences in HRV (e.g., Brown et al., 2018, 2020). Therefore, we made a baseline correction on the HRV data by subtracting the initial baseline measurement (first testing session) from the HRV measures of interest (from sessions 2 and 3) to account for individual differences. A repeated-measures *t* test compared the baseline-corrected relaxation HRV difference scores to the baseline-corrected HeartMath intervention HRV. The *t* test revealed a significant difference between the testing sessions, $t(23) = -2.269$, $p = .033$, Cohen's $d = 0.50$ (refer to Figure 1). These results suggest that there was a significant difference in RMSSD mean difference scores between postrelaxation control ($M = -24.96$ ms, SD = 102.22) relative to post-HeartMath intervention ($M = 35.6$ ms, SD = 137.00). This can be considered a medium effect size, given the commonly used criteria for interpreting Cohen's *d* (Cohen, 1988, admitted that these criteria were arbitrary, and should be interpreted in the context of effect sizes reported in the field; given the relative novelty of HRV research in school settings, we are not aware of relevant comparison values). The HeartMath intervention increased resting HRV compared to relaxation. The mean HRV values decreased from session one, the baseline ($M = 145.77$, SD = 73.17) to the postrelaxation control at the second testing session ($M = 114.11$, $SD = 65.50$), and then increased at session 3 ($M = 178.15$, SD = 101.04) the post-HeartMath intervention. As predicted, the HeartMath intervention increased resting HRV in comparison to a relaxation control (which did not increase HRV).

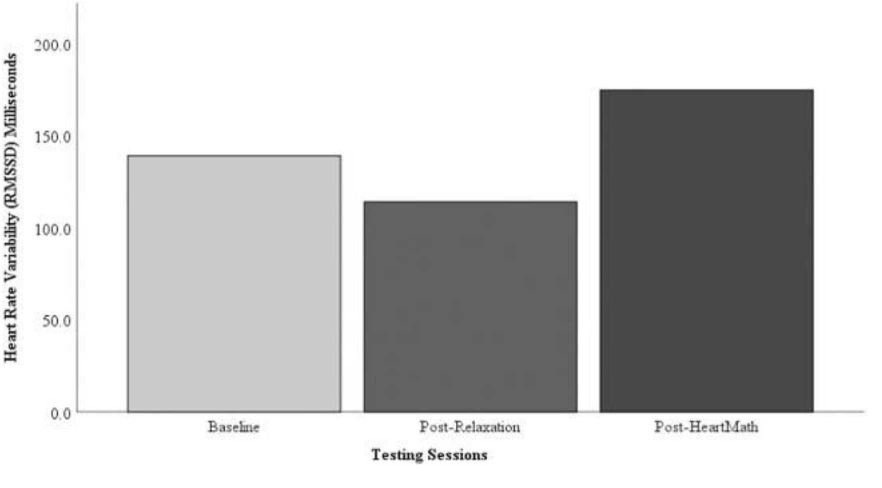

FIGURE 1 Student's heart rate variability (HRV) across all data sessions. HRV values were baseline corrected. RMSSD, root mean squares of successive difference.

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Likert scale questions were designed to assess student perspectives on the value of HeartMath and the likelihood of practicing further at home, school, and so forth. Responses indicated that 75% enjoyed or really enjoyed practicing the HeartMath technique of radiating positive feelings to themselves and others (Heart Lock-In). Overall, 63% of the students found it somewhat or very helpful. Approximately 29% took the practice home to share with parents, family, or friends, and 21% stated that they would likely share it with family or friends. Over half (54%) of students indicated that they were likely or very likely to continue practicing at home. Furthermore, 37.5% mentioned that they were likely or very likely to continue to practice at school, and 37.5% intended to continue to practice frequently or very frequently. The HeartMath intervention seems to have had positive effects on ER as 64% expressed it was helpful to very helpful in managing their emotions. The means are presented in Table 1.

Students also answered open-ended questions to provide qualitative feedback regarding their experiences with using HeartMath practices within real-life contexts as well as their perceptions of the benefits they experienced (refer to open-ended questions in Table 2).

Open-ended responses were themed by two independent coders to ensure interrater reliability on themes. Five recurring and overarching themes emerged across all questions that best described how students were impacted and their experience with practicing HeartMath. These themes are conveyed in an acronym termed HEART (refer to Table 3 for quotes).

The first theme, *Handling Emotions to Regain Composure*, incorporates students' perception of their ability to self-regulate. Second, *Eliciting Positive Feelings* reflects improvements in emotional states. Third, *Awareness of Improvements in Interpersonal Connections*, represents enhancement in interpersonal relationships. Fourth, *Rising*

TABLE 3 Themes of student's feedback regarding HeartMath practice.

Theme	Participant quotes
Handling Emotions to Regain Composure	Helps me control my feelings Wow I can control my feelings when I do HeartMath It helped me with controlling my emotions
Eliciting Positive Feelings	Happy, calm, and content It made me feel different because it made me feel very positive You get to get some rest and let you brain have a break Like I am a good kid Feel really happy for the rest of the day
Awareness of Improvements in Interpersonal Connection	less arguments with friends It makes me feel more happy, and a better friend Feel like a better person I feel that people are more calm when stressful thing happen in class
Rising Performance and Personal Enhancement	I got better at taking deep breaths I feel like a new kid and a younger kid It has made me feel more confident talking to people I have never met or do not see often If I get off task and a little hyper I try to calm myself down by taking a deep breath During my math sheets I could focus better A child is annoying me when I am trying to listen ready to do work
To Practice in Various Settings	During my math sheets I could focus better During a hard test At school I got frustrated and went out to a quiet room and did HeartMath In my bed when I was trying to sleep At home got a little heated Used breathing everywhere if I am frustrated in some way

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Performance and Personal Enhancement encompasses a positive view of self and abilities. The final theme, *To Practice in Various Settings*, conveys various situations in which HeartMath techniques were practiced (the five themes and various sample quotes for each are depicted in Table 3).

3.1 | Handling emotions to regain composure

Students reported that HeartMath practice "helps me control my feelings," 29% stated it assisted in improving ER abilities.

3.2 | Eliciting positive feelings

Results indicated that 79% of the students noticed they felt more "happy, calm, or content" after the practice. A student commented, "it made me feel different because it made me feel very positive." Students reported that it helps them to "feel really happy for the rest of the day."

3.3 | Awareness of improvements in interpersonal connection

Interpersonal improvements and effective conflict management were conveyed in 29% of student comments. They were able to withhold problematic reactions in the middle of interpersonal conflict, and prevent an escalation, by either walking away or regaining their composure before attempting to resolve the dispute. For example, one student reported, "I was in an argument with another kid, I took a deep breath to calm down," another stated, "when I get into an argument at recess I walk away and take a deep breath and get ready to talk about it calmly."

3.4 | Rising performance and personal enhancement

A total of 37.5% of the participants indicated the HeartMath intervention made them feel more confident in their capabilities related to school and ER abilities. In the school setting, students expressed that HeartMath "helped me focus more on school," and "during my math sheets I could focus better." Others illustrated that they utilized the techniques and that it allowed them to stay focused when "a child is annoying me when I am trying to listen," to divert their attention back to classroom learning. It allowed students to be "ready to do work," while able to dedicate concentrated efforts toward their work.

3.5 | To practice in various settings

In total, 67% of the students conveyed they utilized HeartMath in a variety of settings, situations, and scenarios. Locations in which the students practiced were at school, home, and recreational sports facilities. Students particularly emphasized that they utilized the tools while completing school assignments and "during a hard test." Another student reported, "at school I got frustrated and went out to a quiet room and did HeartMath." Students also indicated that they practice at home in their bedrooms before sleeping, "in my bed when I was trying to sleep." A couple of students reported that they had practiced the HeartMath tools "at hockey," and while "playing basketball."

Qualitative feedback supported the beneficial impacts that HeartMath techniques can have on students' ER. These findings provide evidence for the value of implementing ER practices within the school curriculum to enhance student experiences of positive emotionality, academic motivation, attention, and social harmony.

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4 | DISCUSSION

The current study evaluated the effects of a HeartMath ER intervention (Heart Lock-In) within the classroom on students' resting HRV and self-reported ER capabilities. We anticipated the intervention would produce increased coherence in resting HRV measurements (increased HRV), and reports of enhanced ER abilities compared to a relaxation control. The current findings add support to emerging evidence for the benefits of ER strategies. As anticipated, results revealed a significant increase in resting HRV following the HeartMath intervention compared to the relaxation control (which did not increase HRV). These results align with previous research by McCraty et al. (1998), in which there was a reduction in stress hormones, increased coherence in HRV measures, DHEA release, and positive affect from practicing the HeartMath Cut-True method for 30 min, five times a week (a version of the Heart Lock-In). A similar study found marginal improvements in HRV immediately poststudy and significant HRV improvements at the 1-year poststudy follow-up, using a three-step technique like HeartMath practiced for 10 min a day for 4 months (Bothe et al., 2014).

Qahar Sarwari and Nubil Wahab (2018) found HeartMath practices to be effective in positively impacting the HRV patterns of university students. Crucially, the current study highlights that a short daily practice of the HeartMath Heart Lock-In technique can lead to significant improvements in HRV in elementary students. Higher HRV is related to increased resilience to combat various stressors (McCraty, 2015), serving as a protective factor against the initial development and increasing severity of various pathologies, including psychopathologies such as anxiety and depression (McCraty, 2015, 2022; Rovere et al., 1998).

Along with significant HRV findings, qualitative feedback from students reflected their positive experiences with the HeartMath intervention. Students expressed that HeartMath helped alleviate the stress they encountered from school, home, extracurricular activities, or social-related stressors, which is consistent with previous research that delivered a school-based ER intervention (Bothe et al., 2014). This also corroborates findings from a previous study that demonstrated reductions in stress following HeartMath practices, reflected by decreases in the stress hormone cortisol (McCraty et al., 1998).

Students in the current study reported improvements in their skills to self-regulate emotions when unwanted emotions surfaced and increased confidence in self-generating more positive emotions. Such findings parallel previous research that revealed that eliciting positive emotions enhances a person's ability to self-regulate emotions effectively while also inducing a more calming state (McCraty & Zayas, 2014). Likewise, the current HeartMath intervention facilitated the improvement of interpersonal relationship skills, which aligns with Kok et al. (2013) work, revealing that self-inducing positive emotions aid in the development and maintenance of psychosocial well-being.

This research provides further support for theoretical perspectives concerning ER research. Specifically, our findings are in line with Fredrickson's (2001) broaden and build theory as participants experienced physical, emotional, and social benefits from frequently self-inducing positive emotions. This can be seen as evidence of the upward spiral effects of positive emotions. Another theory that helps to explain these findings is the PMER, which purports that emotional experience results from the interplay between one's emotional reaction and ER (Aranberri-Ruiz et al., 2022; Gross, 2015a). Participants were able to regulate emotional experiences and reactions using the HeartLock-In technique. Polyvagal theory (Porges, 1995) holds that emotional reactions are physiologically activated automatically by the vagus nerve via heart rate changes based on perceived risk; a parasympathetic reaction occurs when safety is perceived, whereas a sympathetic reaction occurs in response to threat (c.f. Aranberri-Ruiz et al., 2022). Perhaps self-inducing positive emotions through the Heart Lock-In facilitated increased perceptions of safety and accompanying physiological benefits (such as a more balanced or coherent HRV).

The current study did not directly assess academic performance. However, it is worth noting that students reported experiencing decreased test anxiety from practicing the HeartMath technique. Students indicated that they were able to concentrate better and revert their focus back to classroom learning if their attention veered off

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task. Previous research found similar outcomes in which students reported a decrease in stress levels and test anxiety as well as increased academic performance mediated by HeartMath ER techniques (Bradley et al., 2007; McLeod & Boyes, 2021). Other findings from various studies align with the current qualitative themes and suggest that enhanced socioemotional skills may lead to improvements in test performance and academic success (Bradley et al., 2007; Zins et al., 2007).

Previous studies have demonstrated the benefits of HeartMath ER techniques (McCraty, 2015) from practicing for anywhere from 10 to 50 min over a period of 4 weeks to 4 months (Bothe et al., 2014; McCraty et al., 1998; McLeod & Boyes, 2021). For example, McCraty et al. (1998) had participants practice for 30 min, five times a week, for 4 weeks; Bothe et al. (2014) implemented a 10-min practice daily for 4 months; and the participants in McLeod and Boyes' (2021) study practiced for 50 min two times a week for 4 months. Of the ER literature reviewed, to our knowledge, no studies have found significant impacts on HRV measurements from practicing such techniques in 5-min intervals over 4 weeks. Therefore, this preliminary study contributes to the growing body of ER and HRV literature by illustrating that a significant shift in resting HRV can be accomplished with a very short practice (5 min daily) and over a brief timeframe (4 weeks). The results of the present study provide important practical value to research on HRV among children, which is a relatively new field of research in need of expansion. The simple and short practice utilized in the current study can be easily implemented within school curriculums and classrooms with children of all ages. Current findings suggest it is effective in improving resting HRV as well as self-reported ER abilities, academic performance, and social relationships.

4.1 | Limitations

This study provides important results supporting the effectiveness of HeartMath in an elementary school setting, which can help schools implement effective ER in classrooms. Attempts were made to avoid potential confounds, including assessing students' HRV simultaneously across all three testing sessions. However, as with all research, some possible limitations do warrant mention.

Post-HeartMath intervention testing occurred on the last school day before the government declared school closures due to the COVID-19 pandemic. Students were likely feeling uncertainty from their peers, teachers, and families, which could have impacted attendance rates. In addition, there were extreme winter weather conditions (temperatures in the −30°C range and snowstorm driving conditions). A high rate of subject attrition may have impacted statistical power. With applied research, factors such as these are outside the control of the researchers. Given the circumstances, it is impressive we were able to detect differences in HRV and compile qualitative themes from the sample obtained.

An additional consideration is that 54% of the students indicated they had previously been exposed to HeartMath. The teachers' involved had an awareness of the importance of social-emotional learning. The school is new and located in a higher social-economic status (SES) neighborhood. It would be interesting to replicate this study in a lower SES neighborhood with fewer resources; our findings might have been even more pronounced within a population that may be in greater need of such skills. Alternatively, the effects of ER practices such as these might have been overshadowed by the profound challenges faced in such neighborhoods (e.g., poverty). Comparisons between lower and higher SES schools in ER and HRV are an interesting direction for future research to explore.

Another potential limitation is the small, homogeneous sample of students (predominantly white, all in the same grade and school). Although findings with this sample were promising, the generalizability of the findings obtained to other geographical regions and populations may be limited.

In this study, we did not utilize validated self-report measures to assess changes in ER capabilities. We included tailored Likert-scale questions to assess student perspectives on the value of HeartMath. We also incorporated open-ended questions to gather qualitative feedback regarding elementary student experiences using HeartMath

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practices within real-life contexts. Ivey (2012) argues that open-ended questions can be tailored for participants to express their perceptions and feelings, which allows researchers to better capture participant experiences with practices within real-life contexts. Of course, there is always a risk with self-report measures and qualitative feedback of social desirability bias, it would be wise in future studies to incorporate a measure to control for socially desirable responding to control for this possibility (e.g., Paulhus, 1984).

A final potential limitation to this research was in terms of feasibility; it took nearly 3 h of class time to take each student aside for HRV recordings (measures were taken on two devices equipped with emWave Pro Plus). It is a lot of class time to ask for and can be limiting for future researchers wishing to assess HRV in this manner. This may be one of the reasons that researchers implementing HRVCB training tend to focus on nonphysiological dependent variables such as academic performance and emotional stability (e.g., Bradley et al., 2010; May et al., 2019; McLeod & Boyes, 2021) rather than assessing HRV changes as an outcome variable. In the current study, one 5-min HRV measure was taken per student at each testing period because we were examining resting HRV (not HRV during practice time which was tracked during their practice for their own feedback). This is not an issue for practical settings as HRV information provided in real time by the Inner Balance biofeedback app during practice is considered sufficient to track progress in practical contexts (e.g., therapists, teachers, and children).

It is important to note that the students participated in physical education the morning of each testing session, which could have boosted the students' HRV and moods. However, testing sessions did occur at the same time of day each time in attempts to control for these effects. Notably, significant changes in HRV were found for the HeartMath intervention only, which does support its effectiveness over and above other factors such as exercise.

It is impressive that despite the challenges faced and potential limitations identified, students still experienced a significant increase in HRV after 1 month of consistent HeartMath practice for only 5 min a day. It is possible that the findings would have been even stronger had there been more participants (e.g., greater statistical power), and if the children were even more in need of learning such practices (e.g., from a school with fewer resources).

4.2 | Future directions

Research is needed to assess the HeartMath intervention in lower SES neighborhoods. However, the current study did reveal that a simple, short practice using the Heart Lock-In method for 4 weeks does create significant changes in HRV measurements, which is promising evidence that would be of value to replicate within various contexts. Replication in different samples would also allow further generalizability of the findings to more populations.

Future studies could look to assess the impact of HeartMath practices on validated measures of ER skills in children. For example, including measures such as the Social-Emotional Learning Scale (Evergreen & Coryn, 2012) or the Child Emotion Management Scales (e.g., Zeman et al., 2001, 2010; Ogbaselease et al., 2022) may be of value to further establish the impact of HeartMath on social-emotional learning and ER skills. Another scale that might be of value within this line of research is the Emotion Regulation Questionnaire (Gross & John, 2003) which is one of the most widely utilized measures of ER.

Although students in the current study had no known prior psychological diagnoses (one had Cerebral Palsy), previous studies have found HRV training to be effective amongst children with obsessive-compulsive disorder (OCD), somatoform disorders, and attention-deficit/hyperactivity disorder (Lloyd et al., 2010; Pop-Jordanova, 2009). Research has revealed that a reduction in HRV is a powerful indicator of psychopathology, including anxiety and depression (c.f. McCraty, 2015, 2022). Cartwright-Hatton et al. (2006) acknowledge that anxiety disorders are the most common psychological diagnosis in children and adolescents. These authors also express concern over the limited treatment options available to this population. Early prevention aimed at enhancing ER and resilience shows promise. ER training aimed at increasing HRV has positive effects on children with various psychopathologies. A study by Pop-Jordanova (2009) revealed beneficial outcomes of HRV training for those with anxiety-phobic disorder, OCD, and somatoform disorders. This suggests that children with a range of

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psychopathologies may benefit from such interventions. Those working therapeutically with these populations could look to boosting HRV through HeartMath.

Another interesting avenue is the social aspect of HeartMath applications. For example, in a recent study by McCraty (2017), participants practiced the Heart Lock-In for 5 min in pairs and radiated feelings of care and appreciation to one another. Interestingly, HRV patterns were found to synchronize between both participants. This research reveals that personal coherence can lead to social coherence. Therefore, HeartMath practices can focus on improving individuals' well-being but may also improve relational well-being and social connection (Edwards, 2020; McCraty, 2017). In fact, the HeartMath Institute has a global coherence initiative in which representatives from over 150 countries practice heart-focused care/compassion toward improving interconnectedness and planetary health (Edwards, 2020).

The current study did not directly assess associations between academic performance and HeartMath ER. Recently, McLeod and Boyes (2021) implemented the HeartMath heart-focused breathing technique along with the HeartMath biofeedback in adolescence (a high school psychology course) and found significant increases in test-related self-efficacy, academic achievement, positive affect, and decreased worry about social stressors. However, further research is necessary to examine the impacts of HeartMath practices on academic performance among elementary students.

Future research may wish to include feedback on children's behavior, capabilities, cognitive patterns, and social harmony from parents and teachers. It may also be beneficial to obtain information from the children or their parents regarding the children's level and frequency of physical activity, which can affect HRV patterns. Likewise, requesting dietary intake information could also be advantageous to monitor the systemic impact of food on HRV. A range of factors can impact HRV patterns. Thus, those interested in the study and practice of boosting HRV must be aware of the factors to manipulate or control where relevant.

HeartMath and HRV research in elementary school-aged children is a relatively new field of research with many interesting opportunities for future exploration. Therefore, replication and extension of existing findings are needed.

5 | CONCLUSION

The current study sought to investigate the effects of HeartMath training on resting HRV and self-reported ER experiences. HeartMath practices are ideal for teachers to incorporate into classroom learning as they have been demonstrated to be effective, as they are very simple, accessible to anyone, and can be practiced within a short period of time (minutes).

Notably, the results from the present study support pre-existing literature, specifically in the classroom context, on the benefits of ER practices such as these on improving HRV. Impressively, the intervention (Heart Lock-In for 5 min a day over a period of 4 weeks) significantly increased resting HRV. Elementary students also reported valuable perceived benefits of the practice, such as the increased ability to elicit positive emotions, enhanced interpersonal and conflict management skills, improved ability to focus in school, and tangible effects within various contexts (e.g., school, home, athletics).

Future researchers could conduct similar studies in different samples, including within lower SES schools, within more ethnically diverse contexts, and with other age groups, to allow for either replication and generalizability of the findings and/or contextual differences to emerge. Nevertheless, these findings provide preliminary evidence that simple and short practice can be both practical and advantageous for elementary-aged children. Given the potential practical benefits, school educators, administrators, and counselors may wish to consider implementing HeartMath ER practices consistently within elementary school curriculum and classroom settings.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

Appelhans, B. M., & Luecken, L. J. (2006). Heart rate variability as an index of regulated emotional responding. *Review of General Psychology*, *10*(3), 229–240. https://doi.org/10.1037/1089-2680.10.3.229

Aranberri-Ruiz, A., Aritzeta, A., Olarza, A., Soroa, G., & Mindeguia, R. (2022). Reducing anxiety and social stress in primary education: A breath-focused heart rate variability biofeedback intervention. *International Journal of Environmental Research and Public Health*, *19*, 10181. https://doi.org/10.3390/ijerph191610181

Berntson, G., Quigley, K., Norman, G., & Lozano, D. (2016). Cardiovascular psychophysiology. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (4th ed., pp. 183–216). Cambridge University Press. https://doi.org/10.1017/9781107415782.009

Boehm, J. K., & Kubzansky, L. D. (2012). The heart's content: The association between positive psychological well-being and cardiovascular health. *Psychological Bulletin*, *138*(4), 655–691. https://doi.org/10.1037/a0027448

Bothe, D. A., Grignon, J. B., & Olness, K. N. (2014). The effects of a stress management intervention in elementary school children. *Journal of Developmental and Behavioral Pediatrics*, *35*(1), 62–67. https://doi.org/10.1097/dbp.0000000000000016

Bradley, R. T., McCraty, R., Atkinson, M., Arguelles, L., Rees, R., & Tomasino, D. (2007). *Summary of important findings from the TestEdge National Demonstration Study (TENDS)*. PsycEXTRA Dataset. https://doi.org/10.1037/e503392012-001

Bradley, R. T., McCraty, R., Atkinson, M., Tomasino, D., Daugherty, A., & Arguelles, L. (2010). Emotion self-regulation, psychophysiological coherence, and test anxiety: Results from an experiment using electrophysiological measures. *Applied Psychophysiology and Biofeedback*, *35*(4), 261–283. https://doi.org/10.1007/s10484-010-9134-x

Breit, S., Kupferberg, A., Rogler, G., & Hasler, G. (2018). Vagus nerve as modulator of the brain-gut axis in psychiatric and inflammatory disorders. *Frontiers in Psychiatry*, *9*, 44. https://doi.org/10.3389/fpsyt.2018.00044

Brown, S. B. R. E., Brosschot, J. F., Versluis, A., Thayer, J. F., & Verkuil, B. (2018). New methods to optimally detect episodes of non-metabolic heart rate variability reduction as an indicator of psychological stress in everyday life. *International Journal of Psychophysiology*, *131*, 30–36.

Brown, S. B. R. E., Brosschot, J. F., Versluis, A., Thayer, J. F., & Verkuil, B. (2020). Assessing new methods to optimally detect episodes of non-metabolic heart rate variability reduction as an indicator of psychological stress in everyday life: A thorough evaluation of six methods. *Frontiers in Neuroscience*, *14*, 564123. https://doi.org/10.3389/fnins.2020.564123

Cartwright-Hatton, S., McNicol, K., & Doubleday, E. (2006). Anxiety in a neglected population: Prevalence of anxiety disorders in pre-adolescent children. *Clinical Psychology Review*, *26*(7), 817–833. https://doi.org/10.1016/j.cpr.2005.12.002

Christodoulou, G., Salami, N., & Black, D. S. (2020). The utility of heart rate variability in mindfulness research. *Mindfulness*, *11*(3), 554–570. https://doi.org/10.1007/s12671-019-01296-3

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed). Lawrence Erlbaum Associates.

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Cohen, S., Alper, C. M., Doyle, W. J., Treanor, J. J., & Turner, R. B. (2006). Positive emotional style predicts resistance to illness after experimental exposure to rhinovirus or influenza a virus. *Psychosomatic Medicine*, *68*(6), 809–815. https://doi.org/10.1097/01.psy.0000245867.92364.3c

Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., & Schellinger, K. B. (2011). The impact of enhancing students' social and emotional learning: A meta-analysis of school-based universal interventions. *Child Development*, *82*, 405–432. https://doi.org/10.1111/j.1467-8624.2010.01564.x

Dusenbury, L., & Weissberg, R. P. (2017). Social emotional learning in elementary school: Preparation for success. *The Education Digest*, *83*(1), 36.

Edwards, S. D. (2020). Overview of HeartMath coherence model in advancing health and medical science, *Conference paper from the Academics World International Conference*. Academics World.

Elbers, J., & McCraty, R. (2020). HeartMath approach to self-regulation and psychosocial well-being. *Journal of Psychology in Africa*, *30*(1), 69–79. https://doi.org/10.1080/14330237.2020.1712797

Evergreen, S. D. H., & Coryn, C. L. S. (2012). Social-Emotional Learning Scale. In N. M. Seel (Ed.), *Encyclopedia of the sciences of learning* (pp. 3124–3126). Springer. https://doi.org/10.1007/978-1-4419-1428-6_409

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology. The broaden and build theory of positive emotions. *American Psychologist*, *56*(3), 218–226.

Fredrickson, B. L., Cohn, M. A., Coffey, K. A., Pek, J., & Finkel, S. M. (2008). Open hearts build lives: Positive emotions, induced through loving-kindness meditation, build consequential personal resources. *Journal of Personality and Social Psychology*, *95*(5), 1045–1062. https://doi.org/10.1037/a0013262

Gorman, J. M., & Sloan, R. P. (2000). Heart rate variability in depressive and anxiety disorders. *American Heart Journal*, *140*(4), S77–S83. https://doi.org/10.1067/mhj.2000.109981

Graziano, P. A., Reavis, R. D., Keane, S. P., & Calkins, S. D. (2007). The role of emotion regulation in children's early academic success. *Journal of School Psychology*, *45*(1), 3–19.

Gross, J. J. (2015a). Emotion regulation: Current status and future prospects. *Psychological Inquiry*, *26*, 1–26.

Gross, J. J. (2015b). The extended process model of emotion regulation: Elaborations, applications, and future directions. *Psychological Inquiry*, *26*, 130–137. https://doi.org/10.1080/1047840x.2015.989751

Gross, J. J., & John, O. P. (2003). *Emotion Regulation Questionnaire (ERQ)*. APA PsycTests. https://doi.org/10.1037/t06463-000

HeartMath Institute. (2014). *The resilience advantage: Skills for personal and professional effectiveness (Guidebook)* (Vol. 3). HeartMath Institute. https://doi.org/10.1016/j.jsp.2006.09.002

HeartMath Institute. (2017). *Welcome to Inner Balance*. https://cdn.heartmath.com/manuals/inner_balance_ios_android.pdf

HeartMath Institute. (2020). *Inner Balance coherence sensor*. https://www.heartmath.org/store/products/inner-balance/

HeartMath Institute. (2022). *EmWave Pro Plus*. HeartMath Institute.

Hoffmann, J. D., Brackett, M. A., Bailey, C. S., & Willner, C. J. (2020). Teaching emotion regulation in schools: Translating research into practice with the RULER approach to social and emotional learning. *Emotion*, *20*, 105–109. https://doi.org/10.1037/emo0000649

Ivey, J. (2012). The value of qualitative research methods. *Pediatric Nursing*, *38*(6), 319.

Jarczok, M. N., Koenig, J., Mauss, D., Fischer, J. E., & Thayer, J. F. (2014). Lower heart rate variability predicts increased level of C-reactive protein 4 years later in healthy, nonsmoking adults. *Journal of Internal Medicine*, *276*(6), 667–671. https://doi.org/10.1111/joim.12295

Jones, S. M., & Bouffard, S. M. (2012). Social and emotional learning in schools: From programs to strategies. *Social Policy Report*, *26*(4), 1–33.

Kamberelis, G., Dimitriadis, G., & Ebrary Inc. (2013). *Focus groups from structured interviews to collective conversations*. Routledge.

Kok, B. E., Coffey, K. A., Cohn, M. A., Catalino, L. I., Vacharkulksemsuk, T., Algoe, S. B., Brantley, M., & Fredrickson, B. L. (2013). How positive emotions build physical health: Perceived positive social connections account for the upward spiral between positive emotions and vagal tone. *Psychological Science*, *24*(7), 1123–1132. https://doi.org/10.1177/0956797612470827

Kok, B. E., & Fredrickson, B. L. (2010). Upward spirals of the heart: Autonomic flexibility, as indexed by vagal tone, reciprocally and prospectively predicts positive emotions and social connectedness. *Biological Psychology*, *85*(3), 432–436. https://doi.org/10.1016/j.biopsycho.2010.09.005

Lloyd, A., Brett, D., & Wesnes, K. (2010). Coherence training in children with attention-deficit hyperactivity disorder: Cognitive functions and behavioral changes. *Alternative Therapies in Health and Medicine*, *16*(4), 34–42.

Lutfi, M. (2012). Autonomic modulations in patients with bronchial asthma based on short-term heart rate variability. *Lung India*, *29*(3), 254–258. https://doi.org/10.4103/0970-2113.99111

15206807, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/pits.23025 by Anomi Bearden - Cochrane Canada Provision , Wiley Online Library on [24/07/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

May, R. W., Seibert, G. S., Sanchez-Gonzalez, M. A., & Fincham, F. D. (2019). Self-regulatory biofeedback training: An intervention to reduce school burnout and improve cardiac functioning in college students. *Stress*, *22*(1), 1–8. https://doi.org/10.1080/10253890.2018.1501021

Mazurak, N., Seredyuk, N., Sauer, H., Teufel, M., & Enck, P. (2012). Heart rate variability in the irritable bowel syndrome: A review of the literature. *Neurogastroenterology and Motility*, *24*(3), 206–216. https://doi.org/10.1111/j.1365-2982.2011.01866.x

McCraty, R. (2015). *Science of the heart—Exploring the role of the heart in human performance: An overview of research conducted by the HeartMath Institute* (Vol. 2). HeartMath Institute.

McCraty, R. (2017). New frontiers in heart rate variability and social coherence research: Techniques, technologies, and implications for improving group dynamics and outcomes. *Frontiers in Public Health*, *5*, 267. https://doi.org/10.3389/fpubh.2017.00267

McCraty, R. (2022). Following the rhythm of the heart: HeartMath Institute's path to HRV biofeedback. *Applied Psychophysiology and Biofeedback*, *47*, 305–316.

McCraty, R., Atkinson, M., & Tomasino, D. (2003). Impact of a workplace stress reduction program on blood pressure and emotional health in hypertensive employees. *The Journal of Alternative and Complementary Medicine*, *9*(3), 355–369. https://doi.org/10.1089/107555303765551589

McCraty, R., Atkinson, M., Tomasino, D., & Bradley, R. T. (2006). *The coherent heart: Heart brain interactions, psychophysiological coherence, and the emergence of system wide order* (Publication No. 06-022). Institute of HeartMath. http://www.integral-review.org/issues/vol_5_no_2_mccraty_et_at_the_coherent_heart.pdf

McCraty, R., Barrios-Choplin, B., Rozman, D., Atkinson, M., & Watkins, A. D. (1998). The impact of a new emotional self-management program on stress, emotions, heart rate variability, DHEA, and cortisol. *Integrative Physiological and Behavioral Science*, *33*(2), 151–170. https://doi.org/10.1007/bf02688660

McCraty, R., & Shaffer, F. (2015). Heart rate variability: New perspectives on physiological mechanisms, assessment of self-regulatory capacity, and health-risk. *Global Advances in Health and Medicine*, *4*(1), 46–61.

McCraty, R., & Zayas, M. A. (2014). Cardiac coherence, self-regulation, autonomic stability, and psychosocial well-being. *Frontiers in Psychology*, *5*, 1090. https://doi.org/10.3389/fpsyg.2014.01090

McLeod, C., & Boyes, M. (2021). The effectiveness of social-emotional learning strategies and mindful breathing with biofeedback on the reduction of adolescent test anxiety. *Canadian Journal of Education*, *44*(3), 815–847.

McRae, K., & Gross, J. J. (2020). Emotion regulation. *Emotion*, *20*(1), 1–9. https://doi.org/10.1037/emo0000703

Meeus, M., Goubert, D., De Backer, F., Struyf, F., Hermans, L., Coppieters, I., De Wandele, I., Da Silva, H., & Calders, P. (2013). Heart rate variability in patients with fibromyalgia and patients with chronic fatigue syndrome: A systematic review. *Seminars in Arthritis and Rheumatism*, *43*(2), 279–287. https://doi.org/10.1016/j.semarthrit.2013.03.004

Ogbaselase, F. A., Scelsa, V. L., Stoppelbein, L., Becker, S. P., Fite, P. J., Greening, L., & Luebbe, A. M. (2022). Psychometric properties of the children's emotion management scales within a psychiatric sample. *Psychological Assessment*, *34*(7), 620–630. https://doi.org/10.1037/pas0001131

Paulhus, D. L. (1984). *Balanced Inventory of Desirable Responding*. APA PSYCTests. https://doi.org/10.1037/t08059-000

Pop-Jordanova, N. (2009). *Heart rate variability in the assessment and biofeedback training of common mental health problems in children*. https://www.heartmath.org/assets/uploads/2017/09/hrv-in-the-assessment-and-biofeedback-training-of-common-mental-health-problems-in-children.pdf

Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A polyvagal theory. *Psychophysiology*, *32*, 301–318.

Qahar Sarwari, A., & Nubil Wahab, M. (2018). The effectiveness of the quick coherence technique using heart rate variability-biofeedback technology on the recovery of heart coherence among university students. *Journal of Science & Technology*, *26*(3), 1539–1546.

Rein, G., Atkinson, M., & McCraty, R. (1995). The physiological and psychological effects of compassion and anger. *Journal of Advancements in Medicine*, *8*(2), 87–105.

Rod, K. (2015). Observing the effects of mindfulness-based meditation on anxiety and depression in chronic pain patients. *Psychiatria Danubia*, *27*(1), 209–211. https://doi.org/10.4172/2472-0496.1000111

Rovere, M. T. L., Bigger, J. T., Marcus, F. I., Mortara, A., & Schwartz, P. J. (1998). Baroreflex sensitivity and heart-rate variability in prediction of total cardiac mortality after myocardial infarction. *The Lancet*, *351*(9101), 478–484. https://doi.org/10.1016/s0140-6736(97)11144-8

Sessa, F., Anna, V., Messina, G., Cibelli, G., Monda, V., Marsala, G., Ruberto, M., Biondi, A., Cascio, O., Bertozzi, G., Pisanelli, D., Maglietta, F., Messina, A., Mollica, M. P., & Salerno, M. (2018). Heart rate variability as predictive factor for sudden cardiac death. *Aging*, *10*(2), 166–177. https://doi.org/10.18632/aging.101386

Shahirah Sha'ari, N. A., & Amin, K. M. (2020). Resilience building among university students: A heart rate variability biofeedback study. *Conference Series: Materials Science and Engineering*, *1051*, 012015. https://doi.org/10.1088/1757-899X/1051/1/012015

15206807, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/pits.23025 by Anomi Bearden - Cochrane Canada Provision , Wiley Online Library on [24/07/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Sheikhbardsiri, H., Mousavi, S., Doustmohammadi, M., Karimi, M., & Salahi, S. (2019). The effect of educational workshop on emergency department nurses' self-efficacy in patient training. *Journal of Education and Health Promotion*, *8*, 136. https://doi.org/10.4103/jehp.jehp_52_19

Sheikhbardsiri, H., Sheikhasadi, H., Mahani, S. A., & Mohamadi, M. (2020). Emotional intelligence and learning strategies of postgraduate students at Kerman University of Medical Sciences in the southeast of Iran. *Journal of Education and Health Promotion*, *9*(1), 66. https://doi.org/10.4103/jehp.jehp_544_19

Stein, P. K., Barzilay, J. I., Chaves, P. H. M., Traber, J., Domitrovich, P. P., Heckbert, S. R., & Gottdiener, J. S. (2008). Higher levels of inflammation factors and greater insulin resistance are independently associated with higher heart rate and lower heart rate variability in normoglycemic older individuals: The cardiovascular health study. *Journal of the American Geriatrics Society*, *56*(2), 315–321. https://doi.org/10.1111/j.1532-5415.2007.01564.x

Tooby, J., & Cosmides, L. (1990). The past explains the present. *Ethology and Sociobiology*, *11*, 375–424.

Zeman, J. L., Cassano, M., Suveg, C., & Shipman, K. (2010). Initial validation of the children's worry management scale. *Journal of Child and Family Studies*, *19*, 381–392. https://doi.org/10.1007/s10826-009-9308-4

Zeman, J., Shipman, K., & Penza-Clyve, S. (2001). Development and initial validation of the children's sadness management scale. *Journal of Nonverbal Behavior*, *25*, 187–205. https://doi.org/10.1023/A:1010623226626

Zins, J. E., Bloodworth, M. R., Weissberg, R. P., & Walberg, H. J. (2007). The scientific base linking social and emotional learning to school success. *Journal of Educational and Psychological Consultation*, *17*(2–3), 191–210. https://doi.org/10.1080/10474410701413145

Zins, J. E., Weissberg, R. P., Wang, M. C., & Walberg, H. J. (Eds.). (2004). *Building academic success on social and emotional learning: What does the research say?* Teachers College Press.

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