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Mindfulness Meditation and Interprofessional Cardiopulmonary Resuscitation: A Mixed Methods Pilot Study

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Abstract

Problem: Mindfulness training includes mindfulness meditation, which has been shown to improve both attention and self-awareness. Medical providers in the intensive care unit often deal with difficult situations with strong emotions, life-and-death decisions, and both interpersonal and interprofessional conflicts. The effect of mindfulness meditation training on healthcare providers during acute care tasks such as cardiopulmonary resuscitation (CPR) remains unknown. Mindfulness meditation has the potential to improve provider well-being and reduce stress in individuals involved in resuscitation teams, which could then translate into better team communication and delivery of care under stress. A better understanding of this process could lead to more effective training approaches, improved team performance, and better patient outcomes.

Intervention: All participants were instructed to use a mindfulness meditation device (Muse™ headband) at home for 7 minutes twice a day or 14 minutes daily over the 4-week training period. This device uses brainwave sensors to monitor active versus relaxing brain activity and provides real-time feedback.

Context: We conducted a single-group pretest-posttest convergent mixed methods study. We enrolled 24 healthcare providers, comprising 4 interprofessional code teams, including physicians, nurses, respiratory therapists, and pharmacists. Each team participated in a simulation session immediately before and after the mindfulness training period. Each session consisted of two simulated cardiopulmonary arrest scenarios. Both quantitative and qualitative outcomes were assessed.

Outcome: The median proportion of participants who used the device as prescribed was 85%. Emotional balance, as measured by the critical positivity ratio, improved significantly from pre-training to post-training ($p=0.02$). Qualitative findings showed that mindfulness meditation changed how participants responded to work-related stress, including stress in real-code situations. Participants described the value of time for self-guided practice with feedback from the device, which then helped them develop individual approaches to meditation not reliant on the technology. Time measures during the simulated scenarios improved, specifically, time to epinephrine in scenario 1 ($p=0.03$) and time to defibrillation in scenario 2 ($p=0.02$), improved. Additionally, team performance, such as teamwork ($p=0.04$), task management ($p=0.01$), and overall performance ($p=0.04$), improved significantly after mindfulness meditation training. Physiologic stress (skin conductance) improved but did not reach statistical significance ($p=0.11$).

Lessons Learned: Mindfulness meditation practice may improve individual well-being and team function in high-stress clinical environments. Our results may represent a foundation to design larger confirmatory studies.

Keywords

mindfulness; meditation; cardiopulmonary resuscitation

Introduction

High-risk situations, such as cardiopulmonary resuscitation (CPR), rely not only on the technical skills of medical providers, but also on nontechnical skills, such as leadership, task management, communication skills, and situational awareness. Notably, in the aviation industry, many accidents were related to human errors, which then led to the creation of crisis resource management training with the focus on nontechnical skills.^{1,2} Similar training has been implemented in anesthesia,³ emergency medicine,⁴ and surgery, all of which involve high-risk situations.⁵ For intensive care providers, mastery of nontechnical skills, such as situational awareness, may enhance a provider's ability to carry out difficult tasks and procedures encountered in the critical care environment.

Awareness (both self and team) and attention are critical components to situational awareness (SA), one of the nontechnical skills taught in crisis resource management training, and is particularly important when dealing with tasks associated with high stress. SA is a mental process that comprises perceiving and understanding critical elements of information during a specific task.⁶ This requires being aware of one's surroundings and identification of potential dangers and threatening situations, such as cardiopulmonary arrest. A high-level of SA is vital for medical providers as they are often involved in making life-saving decisions in unpredictable and challenging scenarios.⁷ Poor individual or team SA has been found to be responsible for many human errors.⁸ An understanding of SA and how it affects treatment of patients is now known to be crucial for patient safety and an essential element for research on human factors in critical care environments.⁹ In the healthcare setting, training in nontechnical skills, such as SA, has been shown to improve team behavior,¹⁰ communication and team building,¹¹ and interprofessional teamwork¹² along with a reduction in both errors¹³ and mortality in critically ill patients.¹⁴ Although most CPR training has traditionally emphasized technical skills, newer training models are

increasingly incorporating nontechnical skills as they are important to team performance during a cardiopulmonary arrest. However, training of attention and awareness, components of SA, remains not well understood.

The practice of mindfulness is a training of awareness as it involves the ability to draw attention to the experiences that occur in the present moment without being judgmental of them.¹⁵ In mindfulness practice, non-judgment means recognizing and accepting the continuous flow of fluctuating experiences.¹⁶ Mindfulness meditation is a foundational practice of mindfulness frequently used in mindfulness training and has been shown to improve attention¹⁷ and self-awareness,¹⁸ which could enhance one's awareness of their environment (i.e. SA). In healthcare providers, mindfulness meditation training has been shown to reduce stress and improve provider communication, but much of the current literature has focused on outpatient settings.^{19–21} Additionally, mindfulness has been shown to improve anxiety,²² burnout, and mood.²³ With these potential effects in mind, mindfulness meditation training has a potential role in helping medical providers to improve attention by enhancing emotional buoyancy (i.e. balanced emotions) and decreasing the deleterious effect of negative emotions in decision-making. This may then translate in the provider's ability to deal better with a variety of situations, like CPR, that are charged with strong emotions, difficult decisions, or interpersonal conflict,²⁴ and which effective team communication is essential. The effect of mindfulness meditation training on healthcare providers during acute care tasks, such as CPR, remains unknown. A better understanding of this process could lead to more effective training approaches, improved team performance, and better patient outcomes.

As a first step in advancing this area of resuscitation science, we conducted a convergent mixed methods pilot study to explore the effectiveness and feasibility of mindfulness meditation training for acute care health professionals and its potential impact on individual and team outcomes in a CPR task. We hypothesized that training would result in improvement in individual well-being, resuscitation performance, and teamwork.

Methods

Participants, Setting, and Recruitment

We conducted a study from January to March 2016 using a single group pre- and post-test design. We enrolled a convenience sample of 4 interprofessional code teams with a total of 24 participants, which included Pulmonary and Critical Care Medicine (PCCM) physicians, intensive care unit (ICU) respiratory therapists, ICU pharmacists, and ICU registered nurses. The ICU ancillary staff was sampled from the medical, cardiac, and cardiothoracic ICUs. For each code team, we tried to recruit one physician, one respiratory therapist, 2–3 registered nurses, and one pharmacist. Participants were recruited individually thus the code teams in this study had not previously worked together in a simulated environment. Participation was voluntary with no consequences on the participant's employment. Participants were recruited via email and flyer solicitation. Participants received a moderate financial incentive for participation. This study was approved by the Mayo Clinic Institutional Review Board (IRB#15–004257). Figure 1 describes our study timeline.

Intervention

Mindfulness meditation training programs for health professionals reported to-date require unsupervised practice that makes it difficult to ascertain compliance with the meditation practice and its treatment effect. In this study, all participants were instructed to use the mindfulness meditation device (Muse™ headband) at home for 7 minutes twice a day or 14 minutes once per day to practice mindfulness meditation over the 4-week study period. The Muse™ Brain Sensing Headband is a biofeedback device aimed to train users in meditation that guides breathing awareness, which has been the foundation practice of mindfulness meditation for centuries.^{25,26} The headband is placed on the forehead and connects via a Bluetooth to a free smartphone application. The device has 7 brainwave sensors to monitor active versus relaxing brain activity (through a proprietary algorithm) and provide real-time feedback.²⁷ The Smartphone application can lead the meditation session with breathing guidance if desired by the participant. During the session, the participant is to be fully aware of their breathing and to keep their mind clear. Using the brain sensors on the headband, if the participant is actively thinking, then the background noise becomes loud (i.e. heavy rainfall or waves crashing). However, once the participant's mind is calm, the background noise (i.e. heavy rainfall or waves crashing) quiets down as well. The Muse™ has been previously studied in healthy individuals and found to be effective in distinguishing between 'rational' (instructional) and 'emotional' (recreational) mental states from electroencephalogram data.²⁸ Importantly, Muse™ allows ascertainment of practice compliance, a usual barrier in meditation research. Because of the personalized nature of the practice with instant feedback, its non-obtrusiveness and ability to measure compliance, the Muse™ may represent a useful tool for mindfulness meditation research.

Participants received education on the Muse™ by study investigators (DK, RB) and were allowed a trial run-in period of 1 to 6 days before the start of the study (i.e. before the first simulation assessment) to ensure the technology worked and to troubleshoot any technical difficulties. Training in headband use included viewing a short tutorial provided by the manufacturer and demonstration followed by the opportunity to practice using the device under supervision by study investigators (DK and RB). We also provided a one-page summary of instructions. A study investigator (DK) sent weekly emails to participants to encourage compliance with the Muse™ and was available for technical support as needed.

Outcome Measurements

Outcomes of task performance (resuscitation time, team performance, and individual physiologic stress) and individual emotional balance and emotional intelligence were measured before and after the mindfulness training. We assessed CPR task performance in the Mayo Clinic Multidisciplinary Simulation Center. Each group participated in a simulation session immediately before and after the mindfulness training period. Each session consisted of two simulated cardiopulmonary arrest scenarios using a high-fidelity manikin (LaedraL SimMan 3G). The scenarios were matched for key tasks (shockable or unshockable rhythm) and duration (12 or 15 minutes), but the clinical presentation and underlying etiology for cardiopulmonary arrest varied for each scenario (Supplemental Table 1). All scenarios were computer programmed a priori. All sessions were video recorded. The code teams remained the same for both sessions.

Emotional Balance and Emotional Intelligence—Emotional balance was measured by the “critical positivity ratio” which is derived from the Positive and Negative Affect Schedule, a 20-item self-report questionnaire for positive and negative affect, each using a 5-point response option.^{29–31} This ratio is calculated by dividing the score of the positive affect by the score of the negative affect, and has been reported as a marker of emotional balance or flourishing.³¹ The scores for the critical positivity ratio range between 0 and 2.9 with higher scores representing better emotional balance. It has been tested in various settings (elderly, nursing home residents, marriages, business teams, and college-aged students) with higher ratios correlating with higher levels of flourishing.^{31–34}

The Trait Emotional Intelligence questionnaire-short form (TEIQue-SF) is a 30-item self-report questionnaire used for assessment of emotional intelligence, which has been found to have high reliability (kappa=0.88 female, kappa=0.89 male in a group of healthy volunteers) and moderate-to-high levels of precision based on both item and task information for emotional intelligence.^{35,36} Scores range 30–210, with higher scores suggesting better emotional intelligence.

Skin Conductance (Stress)—We measured skin conductance as a physiological measure of stress using DryQuick Electrodes (Simplex Scientific³⁷). Changes in skin conductance are associated with emotional stimulation: the higher the arousal, the higher the skin conductance.³⁸ Since placing electrodes on the customary location (the palmar aspect of the hand) would interfere with the performance of chest compressions during CPR, we placed electrodes on the participant’s forehead. Monitors were placed approximately 10 minutes before the initiation of the simulation session and were removed immediately after completion of the second simulated scenario.

CPR-Related Performance Outcomes—Team performance was measured in two ways, namely time and ratings of nontechnical skills. Time was marked by a study investigator (DK) from the onset of the scenario to the initiation of chest compressions, first dose of epinephrine, and first defibrillation for each scenario. We measured nontechnical skills using the Team Emergency Assessment Measure (TEAM).³⁶ This rating scale comprises domains of leadership (“team leader let the team know what was expected...”), teamwork (“the team worked together to complete tasks...”), and task management (“the team followed approved standards/guidelines”). This 12-item questionnaire was developed by a team of experts using both qualitative and quantitative techniques with an acceptable content validity index (total item 0.96) and fair reliability (kappa=0.55).³⁶ The first 11 items focus on specific actions using a scale of 0–4 (0=never/hardly ever; 1=seldom; 2=about as often as not; 3=often; 4=always/nearly always). The last item is an overall global rating (“On a scale of 1–10, give your global rating of the team’s performance”). Two study investigators (DK and DN) reviewed each video twice in one sitting and independently filled out the TEAM. Raters were blinded to pre- and post-assessments. We used the average of the scores from the two investigators to determine a final score.

Qualitative Investigation of Participant Experience—All study participants completed a 30-minute individual interview with a study team member trained in qualitative interviewing (DK) at the completion of the study. Interviews were completed in-person or by

telephone based on participant preference. Interviews were audio recorded and audio files were transcribed verbatim by a medical transcriptionist and checked for accuracy. The semi-structured interview guide included questions in three domains: work and life stressors and how the participant typically managed them before the intervention; experience with the mindfulness training (e.g. adherence to practice, barriers to use); and impact of the training (e.g. intervention elements that helped, impact on how the participant manages work or life stressors, intent to continue using mindfulness meditation) (Supplemental Table 2).

Data Analytic Approach

Quantitative Analysis—To analyze both team and individual quantitative outcomes, we compared pre- and post-test scores using paired t-tests. All statistical analyses were conducted using JMP software (version 10.0, SAS Institute, Cary, NC). The effect size (Cohen's d) was determined based on the mean difference and standard deviation (SD) of the pre-assessment.³⁹ A Cohen's d of 0.2 was considered to be small, 0.5 moderate, and 0.8 large.⁴⁰ We report compliance as the median proportion of participants who used the device for at least 14 minutes daily.

Qualitative Analysis—Qualitative data analysis followed procedures similar to those described by Creswell⁴¹ and was consistent with an applied thematic analysis approach, which involves flexible but systematic analysis focused on the study objectives;⁴² in this case, the study objectives were the participants experiences with the training program, their perspectives on its effectiveness, and impact on personal and team outcomes, and opinions that could inform future intervention development and testing. Analysis began with three study investigators (DK, RB, and JR) independently reading the transcripts and making notes in the margins that represent meaning in the text. A list of codes or topics was created based on structural or expected codes (e.g., codes that reflect topics in the interview guide, such as stress-management strategies participants used before and after training), as well as codes that represent emergent ideas (e.g., codes that identify new insights or conceptual issues not predetermined by the interview guide). The use of a detailed codebook ensured reliable use of the coding framework. Code transcripts were entered into NVivo software (NVivo 10.1, QSR International Pty Ltd.) to facilitate data queries. Codes were used to generate themes, which were analyzed across cases. Review of the coded data and team discussion of commonalities and differences across cases were used to identify themes or major findings in the qualitative data. Memos were written during coding and analysis to reflect theme development. The addition of qualitative methods aimed to provide information about acceptability, feasibility, and more in-depth understanding of how participants perceived the impact of the program on individual and team outcomes.

Convergent Mixed Methods Interpretation—Quantitative and qualitative data were first analyzed separately. Study team members then met to discuss the quantitative and qualitative findings using a side-by-side comparison.⁴³ The inclusion of investigators from different fields allowed for multiple perspectives on the data,⁴⁴ and peer debriefing with other researchers was used to minimize interpretive bias.⁴¹

Results

The baseline demographics are seen in Table 1. We enrolled a total of 4 code teams comprising 24 participants, all of whom completed the study. Study results are described in Table 2. Twelve participants (50%) were nurses, a reflection of having 2–3 nurses on each code team. Seventeen participants (71%) were female. The median proportion of participants who used the device as prescribed was 85% over the study period. Half of the participants ($n=7$) used the device for 75% of the days in the study period.

Emotional Balance and Emotional Intelligence

The critical positivity ratio increased from 2.5 to 2.8 (mean difference 0.33; Cohen's $d=0.43$; $p=0.02$), indicating a more positive emotional balance. There was a small improvement in emotional intelligence as per the TEIQue-SF although this did not reach statistical significance, with pre-intervention score 162 and post-intervention score 166 (mean difference 4, Cohen's $d=0.28$, $p=0.16$).

Skin Conductance (Stress)

The measurement of the electrodermal conductance decreased from 8.6 microseimens pre-intervention to 6.4 microseimens post-intervention, but this change did not reach statistical significance (mean difference -2.2 ; Cohen's $d=0.29$; $p=0.11$).

CPR-Related Performance Outcomes

From the baseline assessment to the post-intervention assessment, the time to complete key CPR tasks improved for five of six tasks (three tasks for each of two scenarios), two of which would be considered statistically significant (see Table 2). Time worsened slightly and non-significantly for one task.

For ratings of nontechnical skills, the inter-rater reliability (kappa) for the 11 action-focused items and TEAM overall score was 0.48 and 0.27, respectively. The inter-item reliability for the 11 items was 0.45. There was often only a one point difference in the ratings when there was no agreement, such as an allocation of '2' by one rater and '3' by another. Leadership ratings did not change significantly in either scenario (Table 2). Teamwork ratings significantly improved in both scenarios (1st: 2.5 vs. 3.2, mean difference 0.66, Cohen's $d=1.5$, $p=0.03$; 2nd: 2.6 vs. 3.0, mean difference 0.4, Cohen's $d=1.5$, $p=0.04$). The improvement in task management ratings was statistically significant in the second scenario (2.4 vs. 3.8, mean difference 1.4, Cohen's $d=2.2$, $p=0.01$) but not in the first (2.7 vs 2.9, mean difference 0.2, Cohen's $d=0.61$; $p=0.32$). Global ratings improved for both scenarios (1st: 6 vs. 7.3, mean difference 1.3, Cohen's $d=2.2$, $p=0.03$; 2nd: 5.6 vs. 8.3, mean difference 2.6 Cohen's $d=3.1$, $p=0.04$).

Experience with Mindfulness Training: Qualitative analysis

We conducted individual interviews with all 24 participants with 15 conducted in person and nine by phone. From these interviews, we inductively identified three themes related to the experience of mindfulness meditation training and how participants used new skills in their work or personal lives. These themes are described below along with participant quotes to

exemplify meaning. Quotes are identified by gender, staff role, and ICU years of experience of the participant.

Theme 1: Mindfulness Meditation Training Helps Manage Work-Related Stress

—Participants were asked to reflect on stress-reduction practices before and after the study, and more than half of participants reported that Muse™ changed the way that they managed work-related stress. Strategies for managing work-related stress prior to the study included taking a break, talking with a colleague, and using time after work to exercise or for hobbies – all strategies that remove the participants from the work-stress and give them time away to relax or focus on something else. The Muse™ training provided participants with a new tool for managing stress within the moment. Although the stressors themselves did not change, they noted a difference in how they responded. For example, they used breathing or counting to focus and relax, and were better able to mentally slow down, and reflect before acting.

“I think that it helps having you build up this calmer either mindset or personality so that when it does happen, I’m not totally frazzled; but ‘Alright, I’ve got these things to do, what time is it?’ I can more calmly accept it...I’m not totally holding it all in...” (Female, RN, <1 year ICU experience)

“Our mind really does travel and so just trying to stay centered and keeping it present. That’s what it taught me that’s the biggest thing I’ll take away is how to get re-centered when you think you’re centered and paying attention (Male, MD, 20 years ICU experience).

Those participants who reported finding less impact of the Muse™ training on work-related stress said that what they really needed to change was the work stressors themselves, for example, problems with colleagues or that workload and time pressures of the work made it hard to consistently implement mindfulness.

Theme 2: Mindfulness Meditation Training Helps Teamwork in a Real Code

Situation—Participants described stress in code situations as being related not only to the seriousness of the situation but also to the chaos of having multiple people in the room, which is consistent with the objective to impact both personal and team outcomes using mindfulness meditation. While simulation was used with all participants in this study, some of these individuals also had an opportunity to participate in real code situations during the study period. Their perceptions of the role of mindfulness practice had on their experience was mostly positive and focused on how the training helped them slow down their breathing and maintain calm control.

“I definitely think it was beneficial...I felt more clear in code situation...you can kind of process everything a little bit better. . . . My mind felt clearer.” (Female, RN, 7.5 years ICU experience)

“Yeah, with the code situation . . . and we’re in the middle of a huge crisis, to just sit there and kind of step back for a split second and kind of count and refocus on things.” (Male, RT, 10 years ICU experience)

Mindfulness training was less often described by participants as having an impact on their team interactions, although many of the participants described chaos in code situations as

being better managed when everyone in the room had a role or when the person leading the code was able to focus the situation.

“It’s always nice like when the physician says, okay, let’s slow down, like, we have time; let’s think about things. . . . and then when that physician gives direct orders to people instead of just kind of letting it go run wild.” (Female, patient care assistant, 3 ICU experience)

Theme 3: Structured Mindfulness Meditation Training with Feedback

Facilitates Meditation—Very few participants described doing meditation or practicing mindfulness before the study, although some participants said they did something they considered similar such as practicing music or praying. Participants who had not previously engaged in meditation noted that mindfulness meditation training enhanced their understanding of both the benefits of meditation and their ability to meditate.

“I feel like its opened my eyes to the potential of just meditating instead of kind of trying to do a physical activity, per se. There’s the option to just sit quietly and focus on my breathing, which could help relieve that stress.” (Male, RN, 14 years ICU experience)

One of the primary benefits of the Muse™, as described by participants, was the guided feedback. One participant who had tried meditation unsuccessfully in the past noted that having a device like Muse™ helped keep her mind from wandering. Participants also reported that the mindfulness training encouraged them to set aside dedicated time for personal introspection and that they welcomed those moments of freedom from distraction.

At the same time, participants noted that carving out time for practice was sometimes a burden. Occasional technology glitches distracted from mindfulness practice.

“So I liked that it was an excuse for me to not do anything, cuz I was like, I have to do this cuz I’m part of a study. So I liked that, but at the same time, it was like an obligation, so it was not something that I necessarily enjoyed from the get-go. But I thought it was a good excuse (laughs).” (Female, MD, 3 years ICU experience)

In terms of longer-term impact, participants reported that the combination of dedicated time and guided feedback helped routinize mindfulness practice, although some said that 4 weeks was not enough time to develop their routine discipline. At the completion of the study, several of the participants reported downloading meditation apps on smartphones, planning to learn more about or more regularly practice meditation or yoga, or carving out daily time for relaxation or reflection.

“I was never somebody that really, kind of, did meditation or breathing exercises or anything like that; but I think they are useful and helpful, and I think I’ll continue keeping to try those things.” (Male, MD, <1 year ICU experience)

“I have been trying to continue, just on my own, to take those . . . maybe not 14 minutes but like 10 or 12 minutes a day to do just the breathing exercises.” (Female, RN, <1 year ICU experience)

Discussion

We found that the tested 4-week program of mindfulness meditation for critical care providers was associated with statistically and clinically significant improvements in emotional balance (critical positivity ratio) and resuscitation team performance (teamwork, overall team performance). These findings are consistent with the self-reported perceptions of the intervention improving their personal response to work stressors. Individual physiologic stress (skin conductance), task management, and time to key CPR actions showed a trend toward a difference after the intervention but did not consistently reach statistical significance. Unique to this study, we were able to determine compliance with the intervention and found high compliance with the prescribed use, reporting high acceptability of the technology and satisfaction with the feedback provided by the device.

Prior research studies are consistent with our findings showing that mindfulness can help reduce psychological stress and burnout amongst healthcare providers.^{19,23,45-47} To our knowledge, this study is the first of its kind by focusing on an intervention for ICU providers who have been found to have high burnout.⁴⁸ There is evidence that those with higher critical positivity ratios have more flexibility and resiliency to adversity, more social resources, and improved well-being³¹ and potentially less burnout. We believe our findings of improving the critical positivity ratio are both statistically and clinically significant. Prior research suggests higher positivity ratio is predictive of flourishing mental health or the ability to maintain a healthy balance between both negative and positive emotions.⁴⁹ In our participant interviews, we found that the Muse™ training provided participants with a new tool to use to better manage stress within the moment, which theoretically could improve burnout and overall well-being. Interestingly, participants felt that their overall stressors did not change during the study period, but they were able to notice a difference in how they were able to respond to those stressors; this feedback from participants suggests that they were able to better manage and control their emotions during stressful situations, which would then lead to the development of resiliency, one method of combating burnout. Previous research has shown that dealing with stress better, rather than avoiding stress, is key to better outcomes.⁵⁰

Successful CPR requires a high-level functioning team with both individual and team SA. The improvement seen in resuscitation team performance in this study aligns with prior literature on the effects of mindfulness meditation on healthcare providers. One such study found that mindfulness training was associated with better communication amongst healthcare providers and both patients and peers.^{51,52} Similar benefits in team performance were noted in an inpatient psychiatric ward treatment team after the initiation of mindfulness-based mentoring.⁵³ Mindfulness meditation may enhance SA as it has been shown to improve attention¹⁷ and self-awareness.¹⁸ Additionally, task-unrelated thought (i.e. mind wandering) can compromise attention, increase off-task thinking, and interfere with academic success; however, with mindfulness training, these deleterious effects can be reduced.⁵⁴⁻⁵⁶ Meditation training prepares users to become more self-aware of their own breath and their own emotions with practice; the goal would be for users to be able to learn to control emotions and challenging conflicts during a life-threatening situation (e.g. CPR)

that requires their full attention to the task at hand (i.e. SA). Our study extends this work to suggest benefits of mindfulness training for acute care settings and emergent events.

We acknowledge several limitations to this pilot study. First, in the absence of a control group, we cannot attribute the changes in performance and emotion to the mindfulness training only; changes in CPR performance could also have been caused by learning during the first simulation assessment or increased comfort with the simulation activity with repeated exposure. Second, the simulated scenarios were conducted on a high-fidelity manikin, which may not reflect how the providers would perform in real practice. We attempted to minimize rote performance by varying the clinical presentation and underlying pathophysiology of the cardiopulmonary arrest for each scenario while keeping the appropriate advanced cardiac life support algorithms the same; we acknowledge that observed changes could also be due to differences in the scenarios as scripted. Also, we deliberately matched the duration and salient resuscitation tasks of each scenario and standardized the presentation by pre-programming the scenarios. Third, our failure to identify statistically significant changes in some outcomes could reflect lack of statistical power rather than lack of effect, since this pilot study was primarily intended to explore the feasibility and was not powered to detect small differences. Although our data did not show obvious violations of assumptions for analysis using parametric tests, the small sample and ordinal nature of the rating data represent potential violations. Future studies could use our preliminary findings to ensure adequate power. Fourth, participant's behavior may have been altered simply by being observed (Hawthorne's effect). Lastly, in this study, the inter-rater reliability was poor; future studies should ensure appropriate steps to increase reliability. The strengths of our study include the use of mixed methods to ascertain participants' qualitative impressions of the experience, the use of 2 reviewers for video analysis of team outcomes, and the ability to determine participant's compliance of the intervention mindfulness meditation, which is an innovative aspect of this work as most meditation research relies on self-report.

Our intervention of mindfulness meditation training was associated with improved team outcomes and comments from participants support the idea that meditation training translated to improved calmness and control during actual code events. While not definitive, our findings suggest value in extending this work in studies with better power and stronger controls. While the use of Muse™ seems to be moderately expensive (\$199), it can be used amongst multiple users, offers flexibility in usage, provides real-time feedback, and is relatively user-friendly. Although our study was conducted over a short period of time, the sustainability appears to be high as the faculty involvement is low once trained on the device. Our study found high compliance over a four-week period. Future work could explore both the compliance with and impact of long-term use of mindfulness meditation training.

Conclusion

We believe that our results are important and novel as we found a feasible and acceptable intervention of mindfulness meditation that may improve emotional balance and awareness in a group of healthcare providers that are at risk for burnout. Our findings highlight the

importance of nontechnical skills and provider well-being in delivering optimal care. Nontechnical skills, such as attention and self-awareness, remain remarkably difficult to teach, assess, and maintain. While technical skills in procedures such as CPR will always remain important, a greater understanding of leadership, team management, situational awareness, and emotional control is necessary in order to maximize provider performance and patient outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1:
Study Timeline

Table 1:

Baseline Demographics of the Study Cohort

Demographic	N=24 participants
Gender, female, n (%)	17 (71%)
Clinical experience (in years), median (IQR)	4.3 (2.1, 12.3)
Clinical Practice, n (%)	
Outpatient	1 (4%)
Medical ICU	13 (54%)
Medical/Surgical ICU	3 (13%)
Cardiac ICU	2 (8%)
Cardiac Surgery ICU	5 (21%)
Job Title, n (%)	
Physician	5 (21%)
Resident	1 (20%)
Fellow	3 (60%)
Staff	1 (20%)
Pharmacist	3 (13%)
Registered Nurse	12 (50%)
Respiratory Therapist	3 (13%)
Patient Care Assistant	1 (4%)
Recent Basic Life Support/Advanced Cardiac Life Support Recertification, n (%)	
Unknown	1 (4%)
2013	1 (4%)
2014	9 (38%)
2015	12 (50%)
2016	1 (4%)

ICU, intensive care unit; IQR, interquartile range

Table 2:

Team and Individual Outcomes

	Pre	Post	Mean Difference (95% CI)	P value	Effect Size
Emotional Balance and Emotional Intelligence, mean (SD)					
Critical Positivity Ratio ^A	2.5 (0.8)	2.8 (0.9)	0.3 (0.05, 0.6)	0.02	0.43
Trait Emotional Intelligence Questionnaire (TEIQue-SF) ^B	162 (14.3)	166 (14.9)	4 (−1.4, 7.7)	0.16	--
Skin Conductance (Stress), mean (SD)					
Skin Conductance (microseimens)	8.6 (7.8)	6.4 (6.0)	−2.2 (−4.9, 0.53)	0.11	--
Scenario 1 Time Measure Outcomes, mean (SD)					
Time to Chest Compressions (seconds)	41 (26)	26 (15)	−15 (−68, 37)	0.41	--
Time to Epinephrine (seconds)	119 (44)	84 (27)	−35 (−62, −7.2)	0.03	0.79
Time to Defibrillation (seconds)	527 (129)	410 (81)	−117 (−432, 198)	0.32	--
Scenario 1 TEAM Assessment^C, mean (SD)					
Leadership	2.6 (0.52)	2.5 (0.93)	−0.1 (−1.4, 0.43)	0.89	--
Teamwork	2.5 (0.43)	3.2 (0.51)	0.7 (0.14, 1.2)	0.03	1.5
Task Management	2.7 (0.31)	2.9 (0.32)	0.2 (−0.31, 0.69)	0.32	--
Overall	6 (0.58)	7.3 (0.87)	1.3 (0.22, 2.3)	0.03	2.2
Scenario 2 Time Measure Outcomes, mean (SD)					
Time to Chest Compressions (seconds)	25 (3)	33 (13)	8 (−16, 33)	0.34	--
Time to Epinephrine (seconds)	165 (69)	93 (19)	−72 (−193, 48)	0.15	--
Time to Defibrillation (seconds)	106 (48)	74 (46)	−32 (−53, −9.7)	0.02	0.67
Scenario 2 TEAM Assessment, mean (SD)					
Leadership	2.6 (0.72)	3.1 (0.42)	0.5 (−0.16, 1.0)	0.1	--
Teamwork	2.6 (0.74)	3.6 (0.27)	1 (0.13, 2.0)	0.04	1.5
Task Management	2.4 (0.63)	3.8 (0.13)	1.4 (0.55, 2.2)	0.01	0.61
Overall	5.6 (0.85)	8.3 (0.29)	2.7 (0.16, 5.1)	0.04	3.1

CI, confidence interval; SD, standard deviation

^A Critical positivity ratio measures emotional balance derived from the Positive and Negative Affect Schedule (PANUS) which is a 20-item questionnaire for positive and negative affect, each in using a 5-point response option. The scores can range between 0 and 2.9 with higher scores representing better emotional balance.

^B Trait Emotional Intelligence Questionnaire (TEIQue-SF) is a 30-item questionnaire designed to measure global trait emotional intelligence. The scores range between 30 and 120 with higher scores indicating better emotional intelligence.

^C Team Emergency Assessment Measure (TEAM) is a 12-item rating scale with domains for leadership, teamwork, and task management. The first 11 items focus on specific actions using a scale of 0 to 4 (0=never/hardly ever; 1=seldom; 2=about as often as not; 3=often; 4=always/nearly always). The last question is for an overall global rating ("On a scale of 1–10, give your global rating of the team's performance")