JOURNAL OF
EMERGING INVESTIGATORS

Article

Investigating the impact of electrocardiography biofeedback on POTS symptom management

Sruthi Vallabhajosyula[1], Swarnalatha Duggirala[2]

[1] Rock Hill High School, Frisco, Texas

[2] ITA Group, Celina, Texas

SUMMARY

Postural Orthostatic Tachycardia Syndrome (POTS), a debilitating autonomic disorder affecting a large number of adolescents (ages 15–25), is characterized by symptoms of autonomic dysregulation. Previous research has indicated the potential benefits of electrocardiography (ECG) biofeedback in mitigating some mental health disorders. Thus, we investigated the impact of ECG biofeedback on POTS, using the EmWave Pro equipment as a method of neurofeedback to modulate POTS symptoms in adolescents. Our study aimed to evaluate the consistency of ECG biofeedback in reducing POTS symptoms in terms of intensity and frequency. This method could potentially lead to a more holistic approach to managing POTS, benefiting both patients and healthcare providers. Twenty young adults diagnosed with POTS participated in our study and were instructed to use the EmWave Pro equipment bi-weekly for a period of four weeks. Participants' symptoms were assessed at the start and end of the study using a standardized questionnaire. We hypothesized that consistent use of ECG biofeedback would reduce POTS symptoms in terms of intensity, frequency, and impact on daily life. We found that consistent use of ECG biofeedback significantly reduced POTS symptoms. There was a statistically significant decrease in the number and severity of POTS symptoms reported by participants. In conclusion, ECG biofeedback using the EmWave Pro equipment can significantly reduce the intensity and frequency of POTS symptoms in young adults. Further research is needed to investigate the long-term efficacy of ECG biofeedback in managing POTS symptoms, and to explore the underlying mechanisms that mediate this effect.

INTRODUCTION

Postural Orthostatic Tachycardia Syndrome (POTS) is a condition in which a person experiences a significant increase in heart rate upon standing up from a sitting or lying position, which can lead to symptoms such as dizziness, fainting, and fatigue, and can severely impact quality of life (1). POTS is a relatively common condition, affecting an estimated 1–3 million people in the United States, with a higher incidence among young adults (2). While the underlying causes of POTS are not yet fully understood, there is evidence to suggest that the autonomic nervous system (ANS) may play a role. The ANS is a complex network responsible for regulating the body's automatic processes, such as heart rate, blood pressure, and response to changes in posture. It achieves this regulation through various mechanisms, including the vestibular system, which helps maintain balance and spatial orientation, as well as other factors that influence heart rate and vascular tone (2).

Biofeedback is a technique that allows individuals to gain greater awareness and control over their bodily functions, including heart rate and other autonomic responses (3). Electrocardiography (ECG) is a form of biofeedback that measures the electrical activity of the heart and provides real-time feedback to the individual (4). During ECG biofeedback sessions, participants are able to observe their heart rates in real-time through visual or auditory cues. This means that they can see immediate graphical representations of their heart's electrical activity or hear auditory signals corresponding to their heart rate fluctuations. The real-time feedback empowers participants to understand how their thoughts, emotions, and physical states influence their heart rate patterns (5). By observing these changes, individuals can learn to identify factors that may lead to increased heart rate, such as stress or anxiety, and then apply relaxation techniques or mental strategies to regain control and reduce their heart rate. The ultimate goal of ECG biofeedback is to teach participants how to self-regulate their heart rate and achieve a more balanced and relaxed state (6). A previous study has shown promising results in using ECG biofeedback to manage POTS symptoms by addressing the underlying autonomic dysfunction (7). By improving autonomic regulation, individuals with POTS can experience a reduction in symptoms like tachycardia and improve their quality of life. ECG biofeedback has been used to successfully modulate heart rate and improve symptoms in a variety of conditions, including anxiety and hypertension (8). ECG biofeedback may be a potential therapy for POTS due to its ability to directly address heart rate dysregulation, which is a hallmark feature of the condition linked to dysfunction in the ANS (9). The goal is to empower individuals with POTS to have better control over their physiological responses and improve their overall well-being (10, 11).

In recent years, there has been growing interest in the use of ECG biofeedback as a potential treatment for POTS. One study found that a program of ECG biofeedback combined with cognitive-behavioral therapy led to significant improvements in POTS symptoms and quality of life (12). Participants in this study were aged from 15–25 years old. The length of our current study covers 2 weeks whereas in Nolan et al, 2010 the length was six weeks (13). However, to date, there have been few studies specifically examining the effects of ECG biofeedback alone on POTS symptoms in adolescents. In our study, we created a POTS symptom checklist in order to evaluate the symptoms of each participant.

DOI: https://doi.org/10.59720/23-114

Current treatment of POTS includes changes in diet and water intake, hormonal treatments such as birth control, and in some severe cases, beta-blockers (14). These approaches may not address the underlying autonomic nervous system dysfunction, leaving some patients with incomplete symptom relief. These treatments can also have adverse side effects, with birth control affecting menstrual cycles in women, and beta-blockers having effects on weight and breathing control (15).

In this study, we aimed to investigate the effectiveness of ECG biofeedback in mitigating POTS symptoms among young adults within a relatively brief treatment duration. Our hypothesis posited that individuals undergoing ECG biofeedback would exhibit significant enhancements in symptom management and overall quality of life when contrasted with individuals in the control group. Our research yielded substantial results, indicating that ECG biofeedback indeed plays a pivotal role in ameliorating POTS symptoms among young adults. This intervention demonstrated noteworthy improvements in the participants' well-being, thereby underscoring its potential as a valuable therapeutic tool for this demographic. In conclusion, our study sheds light on the promising utility of ECG biofeedback in the management of POTS symptoms in young adults, highlighting the need for further exploration and implementation of this approach in clinical practice.

RESULTS

We compared POTS symptoms experienced by adolescents with and without ECG biofeedback over a period of four weeks based on intensity and frequency of symptoms (**Table 1**). The study's objective, purpose, and procedures were explained to participants, and written informed consent was obtained before participation. We tested three factors: the severity of POTS symptoms experienced, their frequency, and their impact on daily life. Adolescent POTS patients were asked six questions to assess the intensity and frequency of their symptoms pre- and post-treatment (**Appendix**). Each question presented respondents with answers numbered 1–10, which ranged from weak to strong POTS symptoms/effects on quality of life, respectively. The lowest possible intensity response on a particular question was a score of 1, whereas the highest possible intensity response was a score of 10.

Sociodemographic Characteristics of Participants

Baseline characteristic	Control (N = 10)		Treatment (N = 10)		Total (N = 20)	
	n	%	*n*	%	*n*	%
Gender						
Female	5	50	5	50	10	50
Male	5	50	5	50	10	50
Race						
White	6	60	7	70	13	65
Black/African American	0	0	0	0	0	0
Hispanic	1	10	1	10	2	10
Asian	3	30	2	20	5	25
Previous POTS Treatment						
Yes	3	30	4	40	7	35
No	7	70	6	60	13	65

Table 1. Sociodemographic Characteristics of Participants. The table showcases data related to participants' gender distribution, ethnic background, and relevant medical history that may influence the study outcomes.

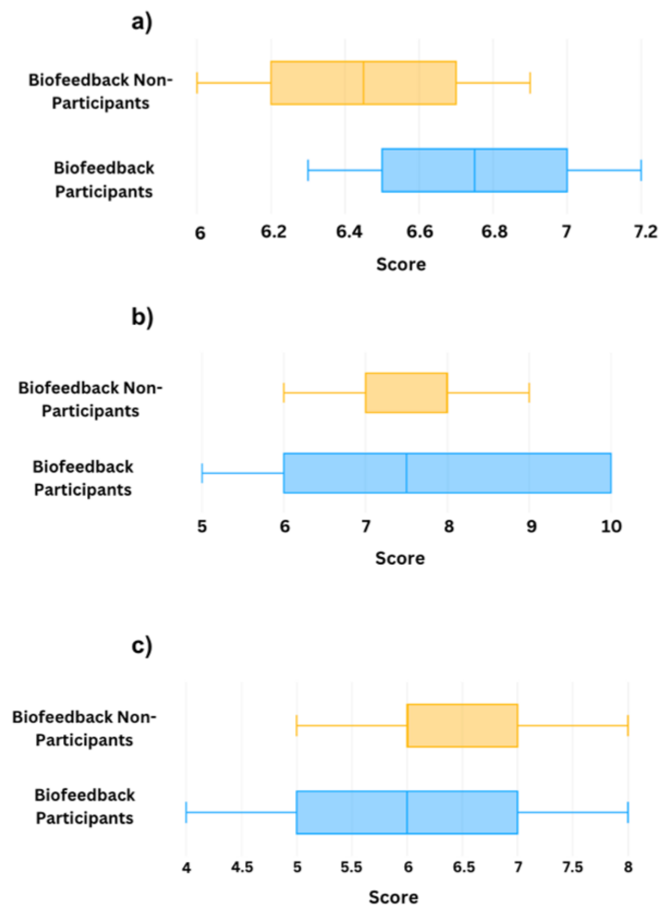

Figure 1. Distribution of the frequency of POTS symptoms, the intensity of POTS symptoms, and the effect that POTS symptoms on daily life among neurofeedback participants and non-participants before treatment. A) By averaging the responses to questions one and two (Appendix Questions 1, 2), the mean intensity scores were calculated for participants who would receive neurofeedback therapy (n = 10) and those who would not (n = 10), as demonstrated in the box and whisker plot. The mean scores were 6.7 and 6.5, respectively. B) By averaging the responses to questions three, four, five and six (Appendix A Questions 3, 4, 5, 6), the mean frequency scores were calculated for participants who received neurofeedback therapy (n = 10) and those who did not (n = 10), as demonstrated in the box and whisker plot. The mean scores were 8 and 7.9, respectively. C) By averaging the responses to questions seven and six (Appendix Questions 7, 8), the mean scores were calculated for participants who received neurofeedback therapy (n = 10) and those who did not (n = 10), as demonstrated in the box and whisker plot. The mean scores were 6.4 and 6.5, respectively. Error bars represent the lowest 25% and highest 25% of responses. The solid lines at the ends of each boxplot represent the minima and maxima of each dataset.

We focused on assessing the severity of POTS symptoms related to dizziness and headaches. Moreover, dizziness and headaches are observable and quantifiable, making them suitable measures for assessing treatment outcomes over a short treatment period (16).

Our first step was to compare the severity of POTS symptoms experienced by participants during the pre-intervention phase. We averaged the scores of the two questions that were aimed at testing the severity of POTS

DOI: https://doi.org/10.59720/23-114

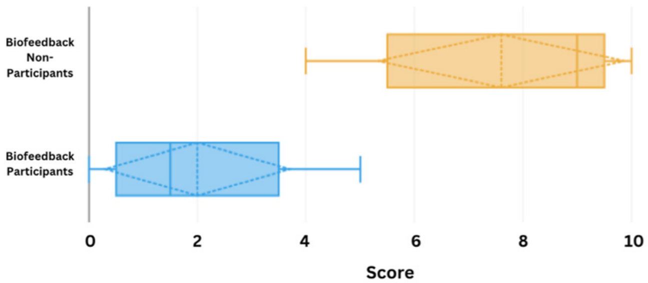

Figure 2. Distribution of the severity of POTS symptoms among neurofeedback participants and non-participants. By averaging the responses to questions one and two (Appendix Questions 1, 2), the mean severity scores were calculated for participants who received neurofeedback therapy (n = 10) and those who did not (n = 10), as demonstrated in the box and whisker plot. The mean scores were 7.6 and 2.0, respectively, with the higher score belonging to the group that did not receive neurofeedback therapy, indicating a greater severity of symptoms A two-sample t-test resulted in p ≈ .00001. Error bars represent the lowest 25% and highest 25% of responses. Dotted vertical lines represent the median of the data. Dotted diagonal lines represent the distance from the mean to both quartile 1 and quartile 3 of the data. The solid lines at the ends of each boxplot represent the minima and maxima of each dataset.

symptoms experienced. Our analysis revealed no significant statistical difference in the severity of POTS symptoms experienced between those who received eight sessions of ECG biofeedback and those who did not during the pre-intervention phase (**Figure 1A)**. Likewise, no statistically significant difference was found in the frequency of POTS symptoms experienced between individuals who underwent eight sessions of ECG biofeedback and those who did not during the pre-intervention phase (**Figure 1B)**. Additionally, there was no statistically significant variance in the impact of POTS on daily life between those who received eight sessions of ECG biofeedback and those who did not during the pre-intervention phase (**Figure 1C)**.

We then tested the severity of POTS symptoms experienced by participants after the treatment had been completed. We averaged the scores of the two questions that were aimed at testing the severity of POTS symptoms experienced. Then, the responses for people who received eight sessions of ECG biofeedback and those who did not were averaged separately to calculate a mean score. The mean score for the ECG biofeedback group was 2.0 ± 1.703 and for the control it was 7.6 ± 2.267 (**Figure 2**). Thus, we found that there was a significant statistical difference in the severity of POTS symptoms experienced between those who received eight sessions of ECG biofeedback and those who did not ($p < 0.00001$, two-sample t-test, **Figure 2**).

Third, for determining the frequency of POTS-related symptoms among both groups, we calculated a mean value score for each participant. We averaged the scores of the four questions that were aimed at testing the frequency of symptoms experienced (**Appendix**). The responses from the second group of questions were averaged. The mean score for the neurofeedback group was 3.65 ± 2.044, and for the control it was 7.2 ± 1.860 (**Figure 3**). The difference was statistically significant, enough to support the second portion of our hypothesis ($p < 0.00001$, two-sample t-test, **Figure 4**).

Furthermore, we assessed changes in physiological measurements, including heart rate variability and other markers of autonomic function, in both the treatment and control groups. However, no statistically significant results were observed in these measures during the four-week treatment period ($p > 0.05$, data not shown).

Finally, to assess POTS' impact on participants' daily lives, we averaged the response scores from the last two questions (**Appendix**). Participants who practiced ECG biofeedback had an overall lower mean score (mean = 3.2 ± 1.720) compared to those who did not practice ECG biofeedback (mean = 6.2 ± 3.215). This was sufficient evidence to suggest that POTS symptoms had less of an effect on ECG neurofeedback participants' lives than nonparticipants ($p = 0.000028$, two-sample t-test, **Figure 4**).

During the four-week period, the treatment group received eight sessions of ECG biofeedback, while the control group received no treatment. The treatment group showed substantial improvement in perceived symptoms and quality of life compared to the control group ($p < 0.05$). No changes in heart rate were observed in the treatment group upon standing, but we observed a reduction in vertigo and exhaustion symptoms ($p < 0.00001$, two-sample t-test, **Figure 4**).

DISCUSSION

In this study, we aimed to investigate the potential benefits of ECG biofeedback on POTS symptoms experienced by adolescents over a four-week period. Our analysis focused on the intensity and frequency of symptoms, as well as their impact on daily life. While we acknowledge that POTS has a wide range of symptoms, we chose these two specific symptoms because they are among the most commonly reported and can significantly impact an individual's daily functioning and quality of life. We hypothesized that adolescents who received ECG biofeedback would show significantly lower scores on all three factors compared to those who did not engage in regular ECG treatment. Frequently administered treatments for POTS, such as beta-blockers and hormonal

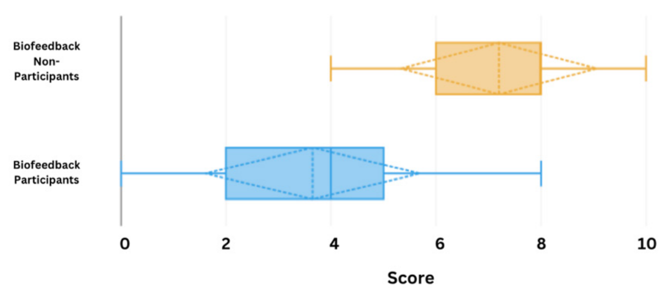

Figure 3. Distribution of the frequency of POTS symptoms among neurofeedback participants and non-participants. By averaging the responses to questions three, four, five and six (Appendix Questions 3, 4, 5, 6), the mean frequency scores were calculated for participants who received neurofeedback therapy (n = 10) and those who did not (n = 10), as demonstrated in the box and whisker plot. The mean scores were 7.2 and 3.65, respectively, with the higher score belonging to the group that did not receive neurofeedback therapy, indicating a greater frequency of symptoms. A two-sample t-test resulted in p ≈ 0.00001. Error bars represent the lowest 25% and highest 25% of responses. Dotted vertical lines represent the median of the data. Dotted diagonal lines represent the distance from the mean to both quartile 1 and quartile 3 of the data. The solid lines at the ends of each boxplot represent the minima and maxima of each dataset.

DOI: https://doi.org/10.59720/23-114

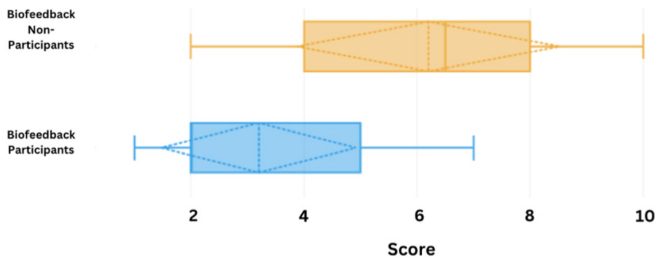

Figure 4. Distribution of the effect that POTS symptoms had on daily life among neurofeedback participants and non-participants. By averaging the responses to questions seven and six (Appendix Questions 7, 8), the mean scores were calculated for participants who received neurofeedback therapy (n = 10) and those who did not (n = 10), as demonstrated in the box and whisker plot. The mean scores were 6.2 and 3.2, respectively, with the higher score belonging to the group that did not receive neurofeedback therapy, indicating a greater POTS-caused impact on daily lives. A two-sample t-test resulted in p = 0.000028. Error bars represent the lowest 25% and highest 25% of responses. Dotted vertical lines represent the median of the data. Dotted diagonal lines represent the distance from the mean to both quartile 1 and quartile 3 of the data. The solid lines at the ends of each boxplot represent the minima and maxima of each dataset.

treatments, tend to have side effects that can be debilitating for some individuals. ECG biofeedback offers a non-invasive treatment method that has minimal to no side effects.

We found that the mean score for the neurofeedback group was significantly lower than the control group, indicating that ECG biofeedback had a positive impact on reducing the severity of POTS symptoms experienced. We found this result to be statistically significant.

Furthermore, we investigated the frequency of POTS-related symptoms by averaging the scores of the next four questions, which assessed the occurrence of POTS symptoms in the participants' lives. The results showed that the mean score for the neurofeedback group was significantly lower than the control group, indicating that ECG biofeedback had a positive impact on reducing the frequency of POTS-related symptoms experienced. This finding was statistically significant as well.

Finally, the study examined the impact of POTS symptoms on participants' daily lives by averaging the response scores from the last two questions, which assessed the effects of POTS symptoms on the participants' daily lives. Our study found that the mean score for the neurofeedback group was significantly lower than the control group, indicating that ECG biofeedback reduced the impact of POTS symptoms on participants' daily lives. Furthermore, this finding was statistically significant.

In contrast to symptom intensity and frequency, changes in physiological measurements, including heart rate variability and other markers of autonomic function, did not show statistically significant differences between the treatment and control groups. While we initially hypothesized that ECG biofeedback would directly impact these physiological markers, it is possible that the short duration of the study or other confounding factors may have influenced the outcomes. Therefore, future research with longer study periods and larger sample sizes is warranted to delve deeper into the effects of ECG biofeedback on autonomic function.

Taken together, our results provide strong evidence to support the use of ECG biofeedback as a potentially effective treatment for POTS symptoms in adolescents. The statistically significant differences between the neurofeedback and control groups in all three factors tested suggest that ECG biofeedback may be a promising intervention for improving the severity, frequency, and impact of POTS symptoms on daily life.

In addition to the findings reported in the study, it is important to consider the potential mechanisms by which ECG biofeedback may be effective in reducing POTS symptoms. One possible explanation is that biofeedback techniques may help regulate autonomic nervous system activity, which is believed to be disrupted in POTS. By providing real-time feedback on heart rate variability, ECG biofeedback may help individuals learn to control their heart rate and improve autonomic regulation, leading to a reduction in symptoms.

There are several limitations to our study that should be noted. First, the sample size was relatively small, consisting of only 20 adolescents with POTS. Thus, the generalizability of the findings to other populations may be limited. Additionally, the study only assessed the effects of ECG biofeedback over a four-week period, which may not be sufficient to observe long-term effects. Future studies with longer follow-up periods are needed to determine the durability of the intervention effects. Another limitation is the lack of blinding of the participants and researchers. Since the intervention group received ECG biofeedback, they may have been more motivated to improve their symptoms compared to the control group, which could have influenced the results. Finally, while the study assessed the effects of ECG biofeedback on symptoms of POTS, it did not evaluate other potential benefits or drawbacks of the intervention, such as its effects on quality of life, medication use, or healthcare costs. Future research should consider these outcomes to fully evaluate the potential benefits and limitations of ECG biofeedback as a treatment for POTS.

Overall, the findings of this study suggest that ECG biofeedback may be a promising intervention for reducing POTS symptoms in adolescents. However, additional research is needed to fully understand the potential mechanisms underlying this effect and to determine whether similar results can be replicated in other populations.

MATERIALS AND METHODS

Participants, Permissions, and Recruitment

An Institutional Review Board (IRB) at Quietmind Foundation reviewed and approved the research plan before it was conducted. The IRB Approval number is IRB00005585. Through advertisements posted on social media platforms and at local healthcare clinics, 20 adolescents (10 males, 10 females, ages 18–23) diagnosed with POTS were recruited for the study (**Table 1**). Participation in the study was voluntary and participants could withdraw at any time without penalty. Participants received ECG sessions twice a week for four weeks, for a total of eight sessions. Data collected from participants would only be used for research and their identities would remain confidential.

Study Design

Study participants were divided into two groups: the intervention group and the control group. Using computer-generated randomization codes, participants were randomly assigned to either the intervention or control group. Each

DOI: https://doi.org/10.59720/23-114

Figure 5: EmWave Pro Software Screen Display. The figure displays a screenshot of the Emwave Pro neurofeedback device's user interface. In the center of the screen, a graph displays the user's heart rate variability (HRV) waveform in a dynamic and fluid manner, depicting fluctuations in heart rate intervals over time. The graph's continuous movements signify the ongoing assessment of the user's HRV coherence level, guiding them towards achieving optimal coherence and emotional balance. The Emwave Pro neurofeedback device allows users to engage in various training modes, and this is reflected in the options presented on the top left side of the screen. The bottom of the interface includes the user's current HRV score, coherence level, and session duration. These metrics enable users to track their progress over time and gain insights into their physiological responses during the neurofeedback training sessions.

ECG biofeedback session lasted around 40 minutes.

The intervention group received eight ECG biofeedback sessions over a four-week period, while the control group did not receive any interventions.

ECG biofeedback sessions were conducted using EmWave Pro software and technology (**Figure 5**). During each session, participants wore ECG electrodes that measured their heart's electrical activity, similar to a standard ECG (**Figure 6**). The EmWave platform processed the ECG signals and provided real-time feedback to the participants on the computer screen.

Data Collection

Data were collected at two time points: pre-intervention and post-intervention. At each time point, participants underwent a standardized assessment that included measures of heart rate, blood pressure, and symptoms associated with POTS. Data were collected using a combination of self-report measures and objective physiological measures. Self-report measures included questionnaires that assessed symptoms of POTS, quality of life, and perceived control over symptoms (**Appendix**). Objective physiological measures, including ECG recordings, were analyzed to assess changes in heart rate variability and other markers of autonomic function.

Data Analysis

Data were analyzed using the SPSS 27 statistical software (IBM) to assess changes in physiological and self-report measures. In our survey, respondents were presented with numbers from 0 to 10. A score of 0 on a particular question indicates the weakest possible intensity response, whereas a score of 10 indicates the strongest possible intensity response. The first two questions were used to assess severity of POTS symptoms experienced. By taking the average responses from the third, fourth, fifth, and sixth questions, we assessed the frequency of these symptoms, and scores from the last two questions assessed POTS' impact on daily life. By finding the "average" of each of the groups and comparing them, we were able to determine statistical significance, using a two-sample t-test to compare the means between the intervention and control groups for the first two questions assessing the severity of POTS symptoms experienced. Results were considered statistically significant if $p < 0.05$.

ACKNOWLEDGMENTS

Throughout the course of this research, Dr. Randall Lyle has been a great source of support and assistance to us. The success of our study could not have been achieved without the guidance, expertise, and unwavering support provided by Dr. Lyle. The expertise and knowledge of Dr. Lyle in the field of neurology and biofeedback have proven essential to guiding the direction of our research. As a result of his insightful comments and suggestions, the methodology and analysis of the data have been refined and improved, resulting in a more robust and comprehensive study. Our sincere thanks go out to Dr. Lyle once again for his invaluable contributions. Our

DOI: https://doi.org/10.59720/23-114

Figure 6: EmWave Pro Setup. In the image, a person is seen using the Emwave Pro, with the device securely attached to their finger. Connected via a cable, the Emwave Pro transmits the heart rate data from the user's finger to the computer. The cable is thoughtfully organized, promoting a seamless and hassle-free connection during the neurofeedback training session. Displayed on the computer screen is the Emwave Pro's user interface, providing real-time visual feedback of the user's HRV. This feedback enables users to observe changes in their heart rate intervals, heightening their awareness of physiological responses and promoting coherence between their heart and mind.

deep gratitude goes out to him for his expertise, guidance, and support during this process.

Received: June 4, 2023
Accepted: July 29, 2023
Published: November 30, 2023

REFERENCES

1. "Postural Tachycardia Syndrome (PoTS)." NHS Choices, NHS, Accessed 9 Oct. 2023.
2. Raj, Satish R. "The Postural Tachycardia Syndrome (POTS): Pathophysiology, diagnosis & management." Indian Pacing and Electrophysiology Journal, vol. 6, no. 2, 84-99, 1 Apr. 2006.
3. Stewart, J M. "Autonomic Nervous System Dysfunction in Adolescents with Postural Orthostatic Tachycardia Syndrome and Chronic Fatigue Syndrome Is Characterized by Attenuated Vagal Baroreflex and Potentiated Sympathetic Vasomotion." Pediatric Research, vol. 48, no. 2, 2000, pp. 218-26. doi:10.1203/00006450-200008000-00016.
4. Bonow, R. O., et al. "Electrocardiography." In Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine, 11th ed., edited by Eugene Braunwald, Saunders Elsevier, 2019, Accessed 9 Oct. 2023.
5. Stafford, Randall S. "Feedback intervention to reduce routine electrocardiogram use in primary care." American Heart Journal, vol. 145, no. 6, 2003, pp. 979-985. doi:10.1016/S0002-8703(03)00107-8.
6. Viljoen, Charle André et al. "Clinically contextualized ECG interpretation: the impact of prior clinical exposure and case vignettes on ECG diagnostic accuracy." BMC Medical Education, vol. 21, no. 1, 417, 3 Aug 2021. doi:10.1186/s12909-021-02854-x.
7. Edwards, J. Guy. "Selective serotonin reuptake inhibitors: a modest though welcome advance in the treatment of depression." British Medical Journal, vol. 304, no. 6843, 27 June 1992, pp. 1644+.
8. Banerjee S, Argáez C. Neurofeedback and Biofeedback for Mood and Anxiety Disorders: A Review of Clinical Effectiveness and Guidelines [Internet]. Ottawa (ON): Canadian Agency for Drugs and Technologies in Health; 2017 Nov 13.
9. Blase, Kees et al. "Neurophysiological Approach by Self-Control of Your Stress-Related Autonomic Nervous System with Depression, Stress and Anxiety Patients." International Journal of Environmental Research and Public Health, vol. 18, no. 7, 2021, pp. 3329. doi:10.3390/ijerph18073329.
10. Frank, Dana L et al. "Biofeedback in medicine: who, when, why and how?." Mental Health in Family Medicine, vol. 7, no. 2, 2010, pp. 85-91.
11. Lehrer, P. M., et al. "Resonant Frequency Biofeedback Training to Increase Cardiac Variability: Rationale and Manual for Training." Applied Psychophysiology and Biofeedback, vol. 25, no. 3, 2000, pp. 177-191. doi:10.1023/a:1009554825745.
12. Nolan, Robert P et al. "Behavioral neurocardiac training in hypertension: a randomized, controlled trial." Hypertension, vol. 55, no. 4, 2010, pp. 1033-1039. https://doi:10.1161/HYPERTENSIONAHA.109.146233.
13. Sheldon, Robert S., et al. "2015 Heart Rhythm Society Expert Consensus Statement on the Diagnosis and Treatment of Postural Tachycardia Syndrome, Inappropriate Sinus Tachycardia, and Vasovagal Syncope." Heart Rhythm, vol. 12, no. 6, Day Month Year (2015), pp. e41-e63. doi:10.1016/j.hrthm.2015.03.029.
14. Tafler, Leonid et al. "Management of Post-Viral Postural Orthostatic Tachycardia Syndrome With Craniosacral Therapy." Cureus, vol. 15, no. 2, 15 Feb 2023, pp. e35009. doi:10.7759/cureus.35009.
15. Whelton PK, et al. "2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines." Hypertension, vol. 71, no. 6, 13 Nov 2017, pp. e13. doi.org/10.1161/HYP.0000000000000066.
16. Das, Arighno et al. "Biofeedback therapy for children: What is the maximum number of sessions we should offer?." Journal of Pediatric Urology, vol. 19, no. 3, 2023, pp. 240.e1-240.e6. doi:10.1016/j.jpurol.2022.11.022

DOI: https://doi.org/10.59720/23-114

APPENDIX

Please respond with a number from 0–10 for each question.

1. On a scale of 0–10, how would you rate the severity of your dizziness/lightheadedness?
   (0 = No dizziness/lightheadedness, 10 = Most severe dizziness/lightheadedness)
2. On a scale of 0-10, how intense are your headaches?
   (0 = No headaches, 10 = Most intense headaches)
3. How often do you experience heart palpitations or a racing heart rate?
   (2 = Never, 4 = Rarely, 6 = Sometimes, 8 = Often, 10 = Almost always)
4. Do you feel short of breath or have difficulty breathing when standing or sitting upright?
   (2 = Never, 4 = Rarely, 6 = Sometimes, 8 = Often, 10 = Almost always)
5. How often do you experience fatigue or weakness, particularly when standing or sitting upright?
   (2 = Never, 4 = Rarely, 6 = Sometimes, 8 = Often, 10 = Almost always)
6. Do you experience nausea or stomach discomfort when standing or sitting upright?
   (2 = Never, 4 = Rarely, 6 = Sometimes, 8 = Often, 10 = Almost always)
7. How often do POTS symptoms impact your ability to attend school or work?
   (2 = Never, 4 = Rarely, 6 = Sometimes, 8 = Often, 10 = Almost always)
8. On a scale of 0-10, how much do POTS symptoms interfere with your daily life?
   (0 = No interference, 10 = Most interference)