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Effectiveness of HRV Biofeedback in Decreasing Anger Among Adolescents With Autism Spectrum Disorder

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Abstract

This study investigates the use of heart rate variability (HRV) biofeedback to manage anger in autistic adolescents. Anger, a natural but potentially maladaptive response to stress, is particularly prevalent among adolescents and is compounded for those on the autism spectrum due to difficulties with sensory processing and communication. Previous research suggests that biofeedback is a promising tool for managing anger. This study examines the effects of HRV biofeedback, both alone and in combination with de-escalation techniques, on reducing anger frequency and intensity among three autistic adolescents. Results show a significant decrease in both anger episodes and intensity during the HRV biofeedback condition, with further reductions observed when de-escalation strategies were added. These improvements were maintained during a 6-month follow-up, indicating the potential for long-term benefits. The study suggests that HRV biofeedback, especially when paired with cognitive-behavioral strategies, may offer an effective, noninvasive, and sustainable approach to anger management for autistic adolescents.

Keywords: anger; autism; adolescence; biofeedback; HRV

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Anger is a natural human emotion that serves as an adaptive response to perceived threats (Fessler, 2010). While anger can motivate individuals to act, its expression often conflicts with societal norms that discourage displays of anger (Dearing et al., 2002). Chronically suppressed anger can become maladaptive when it culminates in aggressive outbursts, violent behavior, or destructive acts (Levey & Howells, 1990; Maiuro et al., 1988). Given the potential social, psychological, and physical consequences of poorly managed anger, it is crucial to understand and address anger as a distinct behavioral concern.

Adolescence is a developmental stage when anger may become particularly pronounced due to the concurrent physical, cognitive, and social changes that characterize this life phase (Wilde, 1995). As adolescents navigate the challenges of increased autonomy, hormonal fluctuations, and shifting parent-child relationships, some may struggle with intensified negative emotions and anger (Steinberg & Morris, 2001). Within the adolescent population, those on the autism spectrum may face unique challenges in managing anger. Challenges with sensory integration and communication can contribute to more frequent or intense anger experiences among autistic youth compared to their neurotypical peers (Quetsch et al., 2023). For example, Quetsch et al. (2023) found that upwards of 50% of autistic adolescents exhibited aggressive behaviors often linked to anger dysregulation. Another study discovered that autistic adolescents self-reported higher levels of repetitive dwelling on angry thoughts (Patel et al., 2016). Therefore, it is essential to develop targeted interventions that address the specific anger management needs of autistic adolescents.

Existing treatments for adolescent anger often encompass medication and treatments that rely on identifying antecedents to anger episodes—such as de-escalation techniques, anger episode recognition skills, and social support. However, many adolescents prone to anger outbursts frequently struggle to identify the precursors to their anger escalation (Mostofsky et al., 2013). Biofeedback training may offer a promising adjunctive therapy for teaching adolescents to recognize anger antecedents. Biofeedback involves using equipment to provide individuals with real-time physiological feedback aimed at increasing self-awareness and promoting voluntary control over bodily responses for improved health and performance (e.g., Lehrer et al., 2000; Lin et al., 2023). Over the years, research has demonstrated biofeedback's efficacy across over 40 health conditions, including anxiety, ADHD, headaches, insomnia, and chronic pain (Frank et al., 2010).

Autistic adolescents with frequent anger episodes may particularly benefit from learning to use biofeedback to identify their anger triggers. One potential physiological marker of anger arousal is heart rate variability (HRV), which reflects the body's stress response. HRV biofeedback involves teaching individuals to modify their breathing patterns to influence HRV and promote relaxation, similar to the principles of mindfulness meditation (Ratajczak et al., 2021). While several studies have explored the use of biofeedback for emotional regulation in adolescents, none have specifically evaluated HRV biofeedback for anger management in autistic adolescents. One study with adults found that short-term HRV biofeedback increased HRV and reduced anger, suggesting that HRV may be an index of anger regulation (Francis et al., 2015). However, the long-term anger management benefits of HRV biofeedback remain unknown and warrant further investigation.

The increasing availability of affordable and user-friendly biofeedback devices that track HRV presents opportunities to make this intervention more accessible. However, the literature lacks studies examining the application of HRV biofeedback for anger management in autistic adolescents. The current study aims to address this gap by evaluating the effectiveness of HRV biofeedback in reducing anger episodes among three autistic adolescents. By acknowledging the unique experiences of autistic individuals and implementing tailored support strategies, we can enhance the anger management skills and resilience of this population.

A Note About Semantics

Identity-first language such as “autistic individuals” rather than person-centered language is used in this article. When communicating about disabilities, it is important to consider how those with the disability refer to themselves, as semantics is significant. Many individuals in the autism community prefer identity-first language because we view autism as a central and inseparable part of our identity (Ryan, 2019).

Methods

Participants

Participants were three adolescents who wanted to learn how to manage their anger, recruited from a mental health clinic that provided counseling services. All participants had (a) an autism spectrum disorder (ASD) diagnosis, (b) a demonstrated history of anger-related behaviors (e.g., yelling, losing temper, arguing) that interfered with daily functioning, and (c) were willing to visit the clinic weekly. A university Internal Review Board (IRB) from the respective university approved the study; participant and parental consent were obtained prior to starting, and participants were assigned an identification number to maintain confidentiality.

Participant 1, an only child, was a 16-year-old male diagnosed with ASD at 6 years of age. He reported challenges controlling his sporadic, daily anger outbursts, which he described as explosive. At the time of the study, he was in the 11th grade and lived with his father.

Participant 2, an 18-year-old male and the youngest of two children, was diagnosed with ASD at the age of 5. He reported experiencing anger episodes daily, and it negatively interfered with him forming and maintaining relationships with others. Participant 2 reported the smallest annoyances would make him angry, and his anger consisted of swearing and yelling. At the time of the study, he was in the 12th grade and lived at home with his parents and siblings.

Participant 3, a 13-year-old male diagnosed with ASD at the age of 4, was in the 7th grade and lived with his mother and twin sibling. Participant 3’s mother reported him exhibiting anger outbursts and yelling at both her and his brother numerous times daily with little warning. Participant 3 reported he liked to tell others what to do and became angry when he did not get his way. At home he physically pushed others, yelled at his mom and brother, and slammed doors. At school he was suspended four times for pushing and swearing at students and teachers.

Setting and Measures

All biofeedback sessions were conducted in a private office at a counseling clinic. A HeartMath emWave2 portable unit was used during the study to measure HRV through an electrode attached to an ear using an ear clip.

Design and Procedure

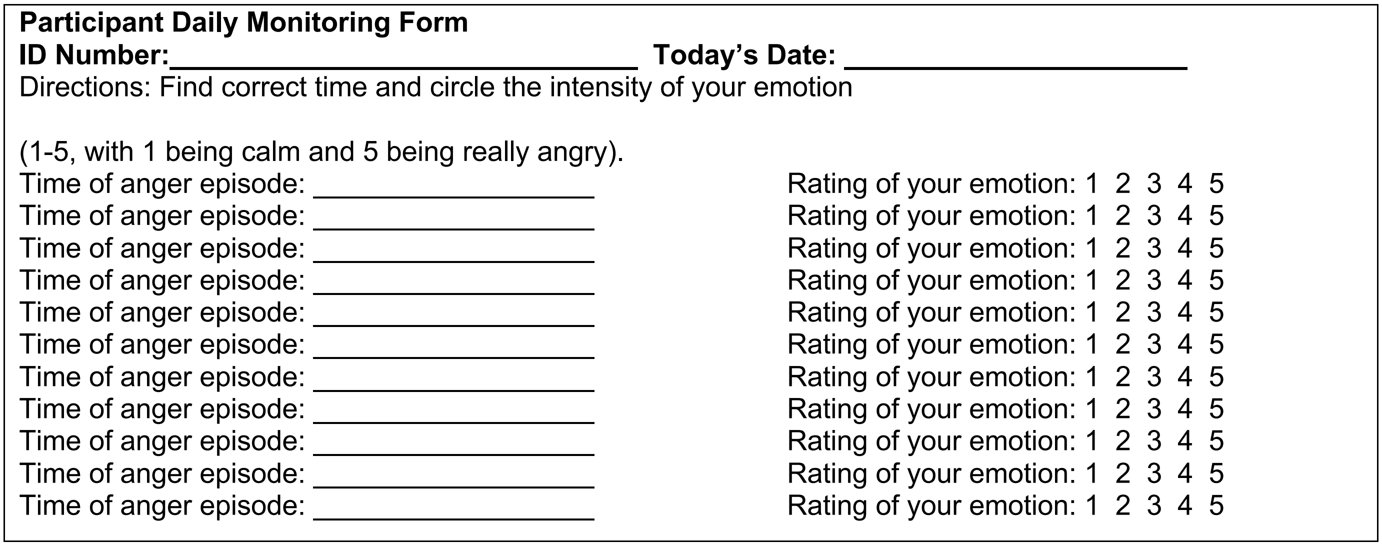
The study used multiple baseline across participants, consisting of baseline, HRV biofeedback condition, HRV biofeedback plus de-escalation techniques condition, and a 6-month follow-up. After baseline, participants completed 15-min HRV biofeedback sessions twice weekly across 4 weeks, followed by 15-min HRV biofeedback sessions along with 10 min of practicing de-escalation techniques twice weekly across 4 weeks, followed by monthly follow-up probes for 6 months.

During baseline, participants recorded the number of daily anger episodes and the intensity of each episode on a recording form (see Figure 1); no interventions were implemented. Prior to starting the HRV biofeedback condition, participants were shown how to use the emWave2 unit—to change the light from red to green—and practiced breathing while connected to the emWave2 unit.

During the HRV biofeedback condition, participants completed a 15-min HRV session, twice a week across 4 weeks, in a private clinic room. For each session, the researcher assisted participants with connecting to the emWave2 unit, then left the room while participants independently completed the HRV session. During the HRV biofeedback plus de-escalation condition, participants completed a HRV session followed by practicing de-escalation techniques with the researcher. During the first HRV plus de-escalation techniques session, participants were taught a four-step de-escalation strategy to use daily whenever they began feeling angry. The four steps were to (1) breathe in slowly for four counts and exhale for four counts, (2) say “I am feeling angry at the moment, and that is okay,” (3) imagine being at your happy place (e.g., skateboarding with a friend, with your dog, at home), and (4) slowly walk away from the situation to another place (e.g., around the school, outside, for a walk or skateboarding).

During the follow-up phase, participants were provided with an emWave2 unit for home use, allowing them to use it at their own discretion rather than following a prescribed frequency. They were instructed to record episodes of anger and their associated intensity using the designated tracking form, as well as to note the frequency of emWave2 usage each week. At the start of each month, participants met with the researcher to submit their completed forms for review.

Figure 1. *Participant Daily Monitoring Form.*



Participant Daily Monitoring Form
ID Number:________________________________ **Today’s Date:** _______________________
Directions: Find correct time and circle the intensity of your emotion

(1-5, with 1 being calm and 5 being really angry).
Time of anger episode: ___________________ Rating of your emotion: 1 2 3 4 5
Time of anger episode: ___________________ Rating of your emotion: 1 2 3 4 5
Time of anger episode: ___________________ Rating of your emotion: 1 2 3 4 5
Time of anger episode: ___________________ Rating of your emotion: 1 2 3 4 5
Time of anger episode: ___________________ Rating of your emotion: 1 2 3 4 5
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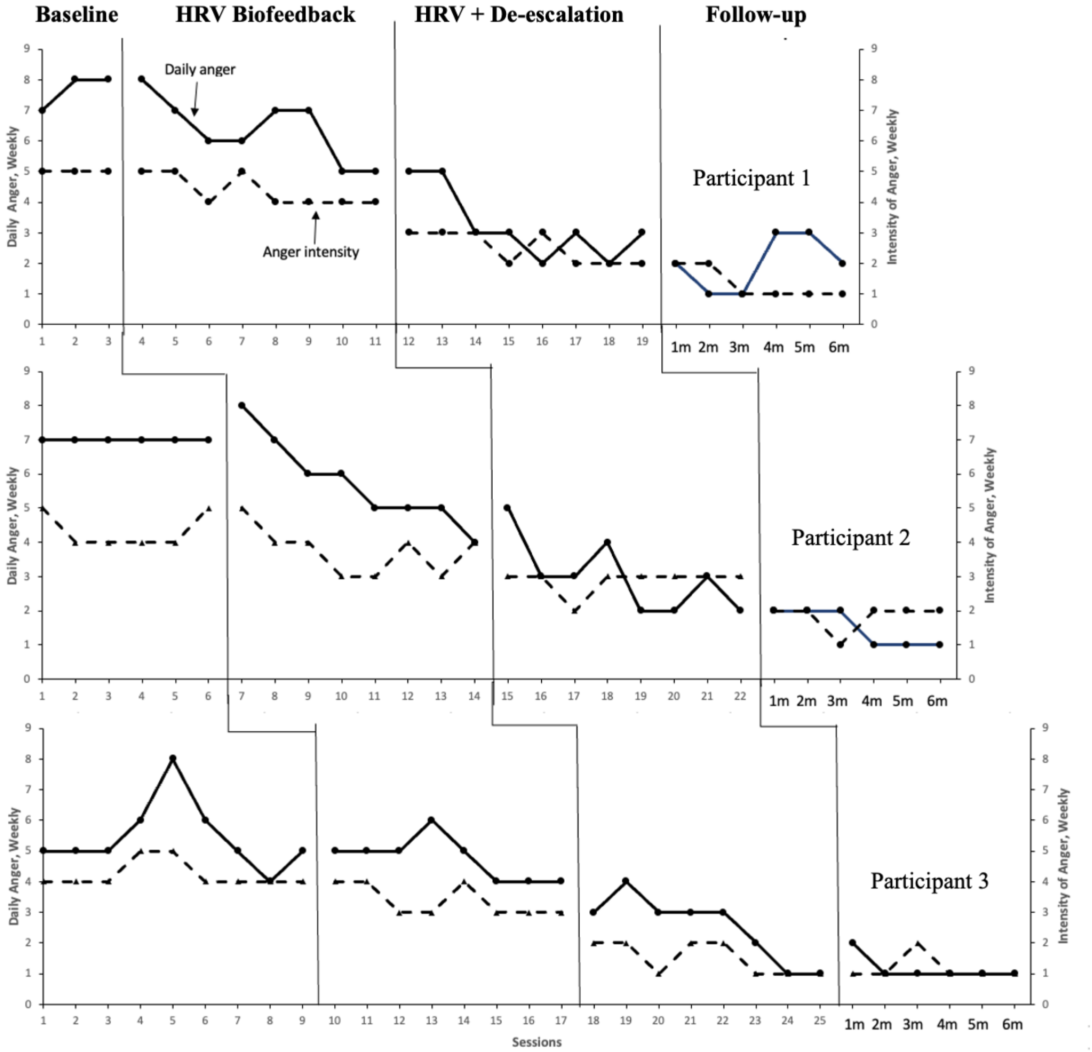
Time of anger episode: ___________________ Rating of your emotion: 1 2 3 4 5
Time of anger episode: ___________________ Rating of your emotion: 1 2 3 4 5
Time of anger episode: ___________________ Rating of your emotion: 1 2 3 4 5

Results

All participants experienced a decrease in anger episodes during the HRV biofeedback condition. A de-escalation component was added to the HRV biofeedback to evaluate whether participants' anger would reduce further. All participants experienced a further decrease in anger episodes during the HRV biofeedback plus de-escalation condition (see Figure 2). During the HRV biofeedback condition, Participant 1 experienced an average of 6.3 anger episodes per day, a decrease from an average of 7.6 daily anger episodes during baseline. His anger episodes further decreased to an average of 3.2 anger episodes daily after the HRV biofeedback plus de-escalation condition was implemented.

Figure 2. *Weekly Anger Episodes (Left Y Axis) and Anger Intensity (Right Y Axis) Across Participants.*



Participant 2 experienced an average of 5.7 anger episodes per day during the HRV biofeedback condition, a decrease from seven daily anger episodes during baseline. His anger episodes decreased further to an average of three daily episodes during the HRV biofeedback plus de-escalation condition.

Participant 3 experienced an average of 4.7 daily anger episodes during the HRV biofeedback condition, a slight decrease from baseline level of 5.4 daily anger episodes. His anger episodes decreased even further, to an average of 2.5 daily angry episodes, during the HRV biofeedback plus de-escalation condition. Anger episodes for all participants decreased further and maintained at low rates during the follow-up condition.

As the number of anger episodes decreased, so did the intensity of the participants' anger (see Figure 2). Participant 1 reported his anger intensity, during baseline, was a 5 (mode = 5). He reported the intensity of his anger decreased to 4 (mode = 4) by the end of the HRV biofeedback condition and decreasing further to 2.5 (mode = 3) by the end of the HRV biofeedback plus de-escalation condition.

Participant 2 reported the intensity of his anger during baseline was 4 (mode = 4). His reported anger intensity decreased to 3.75 (mode = 4) during the HRV biofeedback and decreased further to 2.8 (mode = 3) during the HRV biofeedback plus de-escalation condition.

Participant 3 reported his anger intensity during baseline was 4.5 (mode = 4) and decreasing to 3 (mode = 3) by the end of the HRV biofeedback condition and decreasing further to a 1.5 (mode split between 1 and 2) during the HRV biofeedback plus de-escalation condition.

All participants reported their anger intensity remained at or below the levels observed during the intervention phase during the follow-up period. Furthermore, Participant 1 and Participant 2 reported using the emWave2 device once per week, while Participant 3 reported using the device twice per week during the follow-up phase.

Discussion

The study demonstrated the effectiveness of HRV biofeedback, both alone and in conjunction with de-escalation techniques, in reducing anger episodes among autistic adolescents. Even though participants' anger episodes decreased during the HRV biofeedback condition, the researcher wanted to examine whether an addition of de-escalation techniques that participants used between biofeedback sessions would help further decrease the number of anger episodes. All participants exhibited a significant decrease in both the frequency and intensity of anger episodes, that sustained during the follow-up probes. The results suggest that HRV biofeedback, particularly when paired with de-escalation strategies, could be a valuable tool in managing anger among this population.

One reason for the decreased intensity of anger among participants may be related to the roles of the amygdala and cortisol in the anger response. The amygdala triggers the initial anger response, leading to increased cortisol levels that help manage stress. Cortisol levels peak shortly after anger onset and generally return to baseline within a few hours. If anger occurs again before cortisol levels normalize, the heightened state of arousal and increased sensitivity can lead to more intense anger episodes, since high cortisol amplifies perceptions of threats and makes emotional regulation more difficult, contributing to sustained anger. As participants experienced fewer anger episodes, it is likely their cortisol levels were lower, reducing their sensitivity to triggers that previously caused more intense anger episodes.

The current study adds to the biofeedback literature by (a) evaluating the effectiveness of HRV biofeedback on anger regulation among adolescents, (b) comparing the effectiveness of HRV biofeedback with and without de-escalation techniques, and (c) collecting follow-up data, which is limited in the HRV biofeedback literature.

Strengths

One of the strengths of this study was its focus on personalization and feasibility. The study was implemented in a real-world setting, utilizing a portable HRV device that participants operated independently, demonstrating the practicality of the intervention. This approach not only made the intervention more accessible but also demonstrated its practicality, allowing participants to integrate the practice into their daily lives.

A second strength was the sustained impact observed during the follow-up probes. Unlike many biofeedback studies that did not collect follow-up data after the completion of the intervention (Hillman & Chapman, 2018) this study collected data after the intervention ended, showing a maintained reduction in anger episodes. Collecting data after the completion of the intervention is as important as collecting data during intervention implementation. The consistent reduction in anger episodes even after the intervention ended suggests that the benefits of HRV biofeedback, particularly when combined with de-escalation techniques, sustains beyond the immediate treatment phase. This highlights the potential for long-term effectiveness, offering a lasting solution for helping autistic adolescents manage their anger.

Lastly, the study's multifaceted approach is noteworthy. By integrating HRV biofeedback with de-escalation techniques, the intervention addressed both the physiological and cognitive components of anger management. This comprehensive strategy likely contributed to the overall success of the intervention, as it not only helped participants regulate their physiological responses but also equipped them with practical skills to manage their anger in real-world situations.

Limitations

Even though the study has multiple strengths, it does have areas where future research could improve upon. One of the limitations of this study was the short follow-up condition. Even though the current study included 6 months of follow-up data, future studies should collect longer follow-up data. More research collecting follow-up data on the effectiveness of HRV biofeedback on anger management is needed to demonstrate not just the effectiveness of biofeedback but also the duration of the treatment gains.

Second, since anger does not occur in one setting, success of a biofeedback intervention should be judged based on the ability of participants managing their anger in multiple settings. Unfortunately, the current study did not evaluate generalizability of the biofeedback intervention. More research collecting generalization data is needed to close the gap that exists between demonstrating HRV biofeedback effectively reduces anger in one setting and demonstrating the generalization of HRV biofeedback across multiple settings.

A third limitation of this study was the small sample size of only three participants. This raises concerns about the generalizability of the findings to the broader population of autistic adolescents. While the results are promising, they cannot be confidently extended to a larger group without further research. Future studies utilizing biofeedback for anger management in autistic adolescents should aim to include larger sample sizes, allowing for a more comprehensive understanding of the intervention's efficacy and ensure that the results are representative of a more diverse population.

Fourth, the study's reliance on self-reported measures for anger intensity introduces the possibility of bias. Participants may unintentionally overreport or underreport their anger levels due to subjective interpretations or the desire to present themselves in a favorable light. This could skew the data and impact the accuracy of the findings. Incorporating more objective measures of anger intensity, such as observational assessments or third-party reports, could help mitigate this bias and provide a more accurate reflection of the intervention's impact.

Conclusion

While more evidence is needed to support the effectiveness of HRV biofeedback on anger management among autistic adolescents, the preliminary data gathered in this study suggests that HRV biofeedback plus de-escalation is a promising tool autistic adolescents can use to manage their anger. Continued research on the effects of biofeedback on anger among autistic adolescents is highly recommended since it is less invasive, does not involve medications, and is potentially less expensive and more effective than other counseling or anger management alternatives (Frank et al., 2010; Nordqvist, 2017). With both the frequency and intensity of anger among adolescents on the rise in today's society and given there is little published research in the area, further research studying the effectiveness of biofeedback on anger management of adolescents not only seems necessary but is also strongly encouraged.

Author Disclosure

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