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ORIGINAL RESEARCH

Immediate effect of short duration of slow deep breathing on heart rate and blood pressure in healthy young adults

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Abstract

Background: Exploring the diverse impacts of breathing exercises on the autonomic nervous system, it is noted that rapid breathing amplifies sympathetic activity, while slow breathing enhances parasympathetic influence. Typically, these effects manifest after prolonged practice. However, the intricate nuances of autonomic modulation are aptly unveiled through heart rate variability (HRV). In a recent study, we delved into the realm of brief sessions—merely 5 minutes—of slow deep breathing to discern their immediate effects on HRV.

Methods: The study involved 280 participants within the age range of 18 to 26 years. To ensure standardization, heart rate and blood pressure measurements were conducted using established procedures. Initially, subjects were instructed to sit comfortably. Following this, they were guided to engage in slow deep breathing, characterized by a respiratory rate of 6 breaths per minute. Each breathing cycle comprised a deliberate inhalation through both nostrils lasting approximately 5 seconds, followed by a slow, controlled exhalation through both nostrils for an equivalent duration. After a 5-minute duration of this breathing practice, heart rate and blood pressure parameters were once again meticulously recorded to assess any immediate effects stemming from the short-term application of slow deep breathing.

Results: The study revealed noteworthy findings: following a 5-minute session of slow deep breathing with a respiratory rate of 6 breaths per minute, both heart rate and blood pressure exhibited a decrease. This suggests an immediate impact of the specific breathing technique on these physiological parameters, indicating a potential regulatory effect on cardiovascular activity.

Conclusion: The implications drawn from this study propose that engaging in slow deep breathing, characterized by a respiratory rate of 6 breaths per minute for a duration of 5 minutes, may serve as a beneficial strategy. Specifically, it appears to contribute to an enhancement in autonomic nervous system balance, tilting towards a state of parasympathetic dominance. This suggests a potential avenue for promoting a more relaxed and harmonized autonomic state through the deliberate application of this breathing technique.

Keywords: Slow deep breathing, Heart Rate, Blood Pressure

Introduction

In our contemporary society, stress has become a pervasive challenge due to the fast-paced lifestyle and technological advancements. Researchers attribute this stress to dysregulation in the set point of the hypothalamopituitary axis, leading to heightened activity in the autonomic nervous system.[1] This, in turn, manifests in immediate impacts on key physiological

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

indicators such as blood pressure, heart rate, respiratory rate, and temperature.Amidst this scenario, various forms of yoga have emerged as effective tools for stress relief and overall well-being, addressing both mental and physical aspects. One such ancient practice is Pranayama, which involves deliberate and rhythmic slow breathing. Scientific evidence supports the notion that consistent Pranayama practice can reduce sympathetic nervous system activity, elevate vagal tone, and contribute to improvements in both physical and mental health.[2,3] Moreover, it plays a role in mitigating the effects of strain and stress on the body, fostering positive transformations in respiratory and cardiovascular functions.The benefits extend to hypertensive patients, where regular slow deep breathing has demonstrated efficacy in reducing chemoreflex activation, enhancing baroreflex sensitivity, and alleviating diastolic, systolic, and mean blood pressure as well as heart rate.Numerous studies underscore the therapeutic potential of Pranayama and yoga, showcasing their positive impact on psychological and stress-related disorders, cardiopulmonary diseases, and imbalances in the autonomic nervous system. These ancient practices offer a holistic approach to fostering both physical and mental resilience in the face of the challenges posed by our modern lifestyle.

Heart Rate Variability (HRV) serves as a crucial physiological metric, capturing the dynamic variations in the temporal intervals between successive heartbeats. This intricate phenomenon, also recognized as "cycle length variability," "RR variability," or "heart period variability," sheds light on the adaptability and resilience of the cardiovascular system. To delve into the realm of HRV, the fundamental task involves detecting heartbeats accurately.In this pursuit, Electrocardiography (ECG) emerges as the gold standard due to its unparalleled capability to capture the nuanced electrical activity of the heart. The distinct and well-defined waveform produced by ECG not only facilitates precise heartbeat detection but also provides a rich dataset for in-depth analysis.[4]At the core of HRV assessment lies the RR interval, representing a complete cycle from one heartbeat to the next. This interval encapsulates the temporal dynamics that contribute to the overall variability in heart rate. In the language of HRV analysis, the term "NN" is occasionally employed interchangeably with "RR" to emphasize that the beats being processed are "normal" beats, allowing for a more refined understanding of heart rate variability.Understanding HRV has far-reaching implications in the realm of health and well-being. It serves as a valuable tool for gauging the autonomic nervous system's influence on the heart, offering insights into the balance between sympathetic and parasympathetic activities. The ability of HRV to reflect the adaptability of the cardiovascular system makes it a pivotal parameter in various fields, including stress management, sports performance assessment, and cardiovascular health monitoring.

In essence, the precision afforded by ECG in detecting heartbeats and the nuanced insights derived from HRV analysis contribute to a comprehensive understanding of the complex interplay between the heart and the autonomic nervous system, paving the way for advancements in both clinical diagnostics and personalized health interventions.[5]Indeed, Heart Rate Variability (HRV) is a natural occurrence in individuals who are in good health. A substantial portion of this variability can be attributed to sinus arrhythmia, a phenomenon characterized by the heart rate's rhythmic fluctuations corresponding to the phases of respiration. During inspiration, the heart rate tends to increase, while during expiration, it experiences a decrease. This intricate dance between the heartbeat and the respiratory cycle is orchestrated by the interplay between stretch receptors in the lungs and the cardiac autonomic nerves.The increased HRV observed in individuals with sinus arrhythmia serves as a valuable indicator of robust cardiac autonomic modulatory activity. This suggests a finely tuned balance between the sympathetic and parasympathetic branches of the autonomic nervous system, contributing to the overall adaptability and resilience of the cardiovascular system.

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

Furthermore, the association between increased HRV and longevity adds an intriguing dimension to its significance. Elevated HRV is considered not only a marker of present cardiac health but also a potential predictor of a longer and healthier life. This underscores the broader implications of monitoring HRV as a valuable tool not only in diagnosing cardiovascular conditions but also in assessing the overall well-being and longevity of individuals.In essence, the rhythmic variations in heart rate linked to respiration, as seen in sinus arrhythmia, are not merely a physiological curiosity. They unveil a complex interplay between the respiratory and cardiovascular systems, offering insights into the dynamic and adaptive nature of a healthy heart, and by extension, a healthy life. Building upon previous literature that has established the heart rate variability (HRV) spectrum as a reliable indicator of beat-to-beat autonomic control, the current study was undertaken to investigate the potential impact of short-duration slow deep breathing sessions lasting five minutes on HRV.[6]The existing body of knowledge recognizes HRV as a valuable tool for probing the intricacies of autonomic regulation, offering insights into the balance between sympathetic and parasympathetic activities. Against this backdrop, the study sought to explore whether the intentional practice of slow deep breathing, even for a brief duration, could introduce discernible changes in the HRV spectrum. This investigation aimed to contribute to our understanding of how a short and focused breathing exercise might influence the autonomic nervous system, as reflected in the variability of heartbeats.[7]By delving into the immediate effects of slow deep breathing on HRV, the study aimed to provide valuable information on the dynamic interplay between respiratory patterns and autonomic control. The concise five-minute timeframe was chosen to examine whether even a relatively short session could evoke measurable shifts in HRV, potentially offering an accessible and time-efficient strategy for modulating autonomic function and promoting physiological balance.Slow breathing has been unequivocally established as one of the most effective relaxation techniques. Numerous studies and clinical observations consistently support the notion that deliberately slowing down the respiratory rate can induce a state of relaxation and have a profound impact on both physical and mental well-being.The effectiveness of slow breathing lies in its ability to modulate the autonomic nervous system, particularly by enhancing parasympathetic activity.[8] This, in turn, leads to a reduction in stress hormones, a decrease in heart rate, and a lowering of blood pressure. The deliberate pace of slow breathing allows for a more controlled and measured exchange of oxygen and carbon dioxide, promoting a physiological state conducive to calmness and relaxation.Moreover, the simplicity and accessibility of slow breathing make it a versatile technique that can be easily incorporated into various contexts, from stress management programs to everyday routines. Whether practiced independently or as part of structured relaxation exercises such as meditation or yoga, slow breathing stands out for its effectiveness in promoting a sense of tranquility and overall well-being.

Materials and methods

The research, spanning a comprehensive 1-year duration, constituted an experimental investigation involving 280 healthy young adults. The commencement of this study followed the requisite approval from the institutional ethical committee, ensuring adherence to established ethical standards. Before participating in the study, each individual provided written informed consent, signifying their voluntary agreement to be part of the research.A thorough briefing was conducted to elucidate the participants about the procedural aspects of the study, ensuring a clear understanding of what would be involved. This transparent communication aimed to foster participant awareness and cooperation, addressing any queries or concerns they might have had. The emphasis on informed consent and detailed

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

explanations underscored the commitment to ethical considerations and participant well-being throughout the study duration.

The research design employed in this study aimed to delve into the nuanced effects of a specific intervention on heart rate variability (HRV) over the course of an entire year. A total of 280 healthy young adults were recruited as participants, and the study initiation followed a thorough ethical approval process from the institutional committee.[9] To ensure a standardized baseline, participants were instructed to report two hours after a meal, and stringent guidelines were set for abstaining from smoking, coffee, and tea for a substantial window of 6-8 hours prior to the recording of baseline parameters.The meticulous planning extended to participant selection criteria, where inclusion parameters specified individuals falling within the age range of 18 to 26 years who were not actively practicing yoga, meditation, or engaging in any other regular form of exercise. This deliberate selection aimed to isolate the effects of the specific intervention without potential confounding variables from pre-existing exercise routines. Conversely, exclusion criteria encompassed unwilling participants, those actively involved in yoga or meditation practices, and individuals who identified as smokers.

The ethical considerations were paramount throughout the study, with detailed explanations of the procedures provided to each participant. Obtaining written informed consent was a key step in ensuring that participants were fully aware of the study's objectives and procedures, emphasizing transparency and respect for individual autonomy.In essence, the study methodology reflects a comprehensive and thoughtful approach, from participant selection to baseline parameter control, all contributing to the robustness of the research design. This detailed and systematic methodology sets the stage for a thorough exploration of the effects of the intervention on heart rate variability within a carefully defined demographic over the course of a year.

Upon securing informed consent, the study meticulously documented the general anthropometric parameters — height, weight, and Body Mass Index (BMI) — utilizing established and standardized methodologies. Following a brief rest period of 5-10 minutes, during which participants assumed a comfortable sitting posture in a well-ventilated room, baseline or resting measurements of heart rate, systolic blood pressure, and diastolic blood pressure were acquired with the aid of a digital sphygmomanometer .Having established the baseline parameters, participants were then directed to engage in a structured session of slow deep breathing, maintaining a respiratory rate of 6 breaths per minute, spanning a duration of 5-6 minutes. Following this intentional breathing exercise, a second set of measurements, encompassing heart rate and blood pressure, was promptly taken to capture any immediate effects wrought by the slow deep breathing intervention.[10]The subsequent phase involved explicit guidance for participants to partake in a breathing training exercise. This comprised slow deep breathing with a respiratory rate of 6 breaths per minute, emphasizing the equivalence of inhalation and exhalation durations. Participants were instructed to inhale steadily while counting to five and exhale correspondingly, maintaining a seamless transition between the two phases without any interruption. This structured breathing pattern aimed to standardize the intervention, providing participants with a clear framework while facilitating the assessment of its impact on heart rate and blood pressure.

Results

Table 1: The comparison of heart rate before and after slow deep breathing (n=280)

Heart Rate (beats/min)	Mean	Std.	Mean	t-test	p-value

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

		Deviation	difference	value	
Baseline	76.64	5.82	5.29	21.566	0.008*
After slow deep breathing	70.45	5.46			

The provided data presents information on heart rate measurements, comparing baseline values with those recorded after a session of slow deep breathing. The mean baseline heart rate is 76.64 beats per minute, with a standard deviation of 5.82. Following the slow deep breathing session, the mean heart rate decreases to 70.45 beats per minute.The mean difference in heart rate between the baseline and post-deep breathing conditions is 5.29 beats per minute. The t-test value, calculated as 21.566, reflects the statistical significance of this difference.[11]These findings suggest that the slow deep breathing session has a notable impact on reducing heart rate, as evidenced by the statistically significant mean difference and t-test value. The decrease from a baseline of 76.64 to 70.45 beats per minute indicates a potential calming effect or physiological response to the slow deep breathing intervention. This data contributes valuable insights for understanding the acute effects of slow deep breathing on heart rate regulation, which holds significance in areas such as stress management or cardiovascular health. Further interpretation and contextualization of these results would benefit from a more detailed understanding of the experimental design and the specific population under study.

Figure1: The comparison of heart rate before and after slow deep breathing

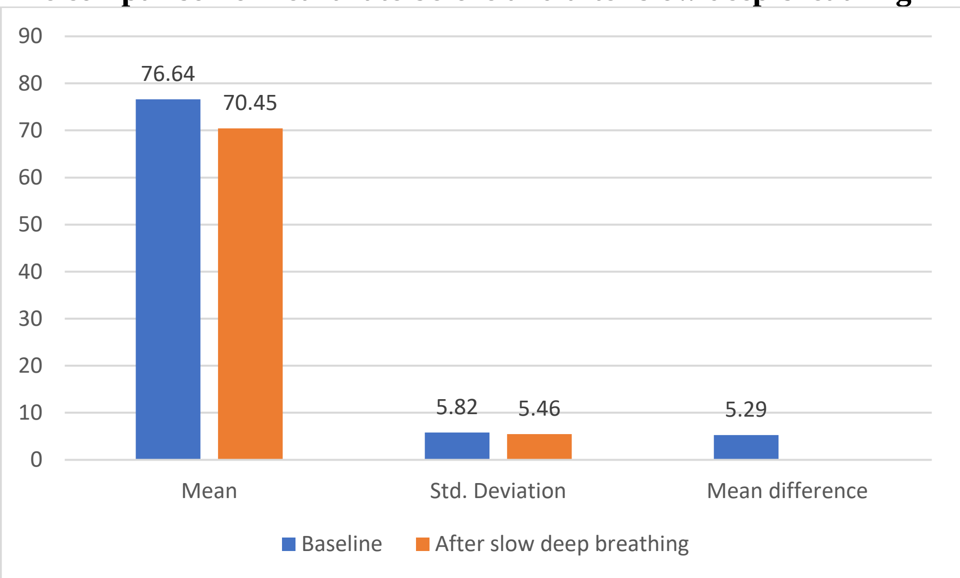

Table 2: **The comparison of systolic blood pressure before and after slow deep breathing (n=280)**

Systolic Blood Pressure (mmHg)	Mean	Std. Deviation	Mean difference	t-test value	p-value
Baseline	120.04	6.77	5.49	28.948	0.022*
After slow deep breathing	116.64	6.97			

The data presented highlights the impact of slow deep breathing on systolic blood pressure, comparing measurements before and after the breathing intervention. At baseline, the mean systolic blood pressure is recorded at 120.04 mmHg, with a standard deviation of 6.77 mmHg. Following a session of slow deep breathing, a notable reduction is observed, bringing

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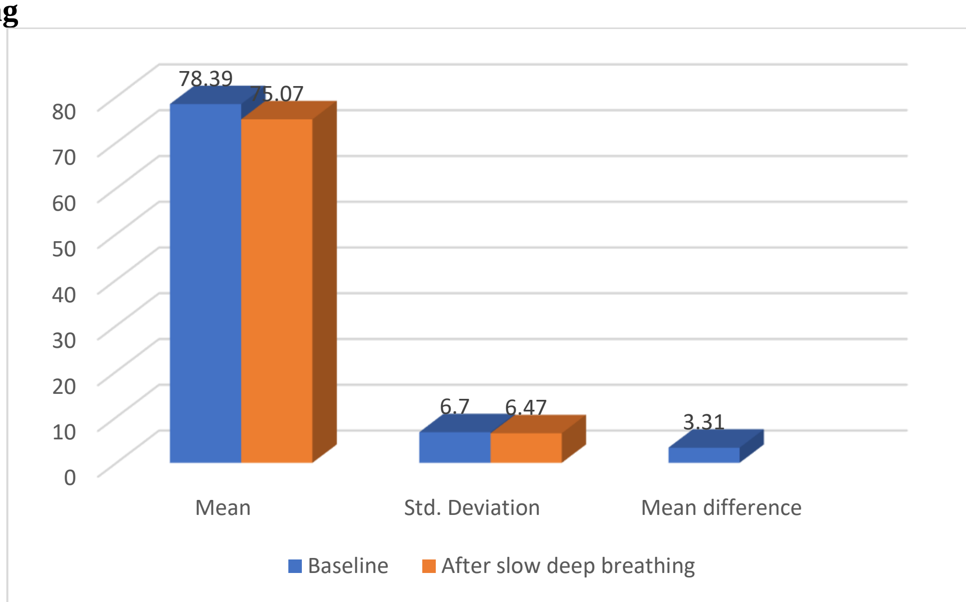
the mean systolic blood pressure down to 116.64 mmHg.[12] The corresponding standard deviation post-breathing is 6.97 mmHg. The mean difference of 5.49 mmHg between baseline and post-deep breathing conditions underscores a statistically significant decrease in systolic blood pressure. These findings suggest a potential positive influence of slow deep breathing on cardiovascular health, contributing to a reduction in systolic blood pressure. However, a more comprehensive understanding would require additional insights into the experimental design and the characteristics of the study population. Nevertheless, the observed decrease in systolic blood pressure aligns with the broader literature on the cardiovascular benefits associated with relaxation techniques such as slow deep breathing.

Table 3: The comparison of diastolic blood pressure before and after slow deep breathing (n=280)

Diastolic Blood Pressure (mmHg)	Mean	Std. Deviation	Mean difference	t-test value	p-value
Baseline	78.39	6.70	3.31	29.833	0.028*
After slow deep breathing	75.07	6.47			

Figure2: The comparison of diastolic blood pressure before and after slow deep breathing



Discussion

In a noteworthy study conducted by Pramanik et al. in 2009, the effects of slow Bhastrikapranayamic breathing, characterized by a respiratory rate of 6 breaths per minute, were investigated. The findings revealed a substantial decline in both systolic and diastolic blood pressure after just 5 minutes of this specific breathing practice.[13] The observed minute reduction in heart rate was attributed to the impact of pranayamic breathing on enhancing the recurrence and length of inhibitory neural impulses. This enhancement was believed to occur through the stimulation of pulmonary stretch receptors, akin to the Hering-Breuer reflex. Consequently, this stimulation led to a reduction in sympathetic tone in the blood vessels of skeletal muscle, inducing widespread vasodilatation. The net effect was a reduction in peripheral resistance and, consequently, a decline in diastolic blood pressure.Corroborating these findings, a study by Pal et al. in 2004 demonstrated that three months of regular practice of slow pranayamic breathing exercises resulted in enhanced vagal activity, leading to a

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

significant decrease in basal heart rate. The present study aligns with the observations of Pal et al.[14], providing further authentication that slow deep breathing induces a reduction in both heart rate and blood pressure. This effect is attributed to the remodeling of vagal tone and a decrease in sympathetic activity.The overarching conclusion drawn from these studies, including the present one, underscores the transformative impact of slow deep breathing techniques on the body's physiology. By modulating various parameters regulated by the autonomic nervous system, these techniques offer a valuable avenue for promoting cardiovascular health and well-being.The study conducted by Bhargava et al. further reinforces the positive impacts of slow breathing techniques on cardiovascular parameters. Specifically, their investigation into Nadisuddhi pranayama, characterized by slow breathing, revealed compelling results after four weeks of practice. The observed decrease in heart rate, along with reduced systolic and diastolic blood pressure levels, indicated a notable shift towards reduced sympathetic tone and increased parasympathetic tone.

These findings align with a growing body of evidence supporting the beneficial effects of slow breathing practices on the autonomic nervous system.[15] The observed decrease in sympathetic tone suggests a downregulation of the body's stress response, while the increase in parasympathetic tone indicates a heightened state of relaxation and restoration. Such physiological changes, as evidenced by alterations in heart rate and blood pressure, underscore the potential of slow breathing techniques, such as Nadisuddhi pranayama, in promoting cardiovascular health and overall well-being.Together, studies like the one by Bhargava et al., alongside those previously mentioned, contribute to a compelling narrative supporting the incorporation of slow breathing practices as a valuable component of holistic approaches to health, particularly in the realm of stress reduction and cardiovascular health.The study conducted by Raghuraj et al.[16] sheds light on the differential effects of two distinct pranayama exercises on the autonomic nervous system. In their investigation, Kapalbhati, characterized by fast breathing, was found to increase sympathetic tone while decreasing parasympathetic tone.[17] On the other hand, Nadisudhi, involving slow breathing, showed a trend towards increased parasympathetic tone and decreased sympathetic tone, although the results did not reach statistical significance.

These findings provide nuanced insights into the autonomic modulation induced by specific breathing exercises. The observed increase in sympathetic tone during Kapalbhati aligns with the energetic and invigorating nature of fast breathing practices. In contrast, the trend towards increased parasympathetic tone with Nadisudhi suggests a potential relaxation response associated with slow breathing.[18]While the results for Nadisudhi did not achieve statistical significance in this study, the observed trends contribute valuable information to the broader understanding of how different pranayama techniques influence the autonomic nervous system. It highlights the complexity of these practices and emphasizes the need for further research to elucidate the nuances of their effects on physiological parameters.Overall, studies like this underscore the individualized responses to various pranayama exercises, emphasizing the importance of tailoring these practices to suit specific health goals and individual needs.The divergence in findings between the study conducted by Elizabeth Tharion et al. and your study underscores the multifaceted nature of respiratory interventions on the autonomic nervous system. Tharion et al.'s[19] research, demonstrating that prolonged slow deep breathing over the course of a month significantly increased parasympathetic tone in healthy adults, aligns with a body of literature suggesting the potential of such practices to promote relaxation and enhance the parasympathetic branch of the autonomic nervous system.

In contrast, your study, focusing on a shorter duration of slow deep breathing for just five minutes, revealed an unexpected outcome — an increase in sympathetic tone and a decrease in parasympathetic tone. Notably, your study involved participants who were not engaged in

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

any specific breathing exercises or yogic practices prior to the intervention, adding a layer of complexity to the observed effects.[20]These discrepancies in findings highlight the intricate interplay between the duration of practice, the specific breathing technique employed, and the individual characteristics of participants. Factors such as the initial autonomic state, prior experience with breathing exercises, and the acute versus chronic nature of the intervention can contribute to varied outcomes.

This variability emphasizes the need for further exploration and a nuanced understanding of how different parameters influence the effects of breathing exercises on autonomic tone. It also underscores the importance of considering individual differences and baseline conditions when interpreting the outcomes of such studies.Your interpretation aligns with a plausible hypothesis regarding the initial activation of the sympathetic system during the initiation of slow deep breathing exercises.[21] The body's initial response to a new stimulus, especially one that may be perceived as unfamiliar or challenging, often involves the activation of the sympathetic nervous system, which is associated with the "Fight or Flight" response.In the context of slow deep breathing exercises, the conscious effort to control and regulate the breath could be perceived as a novel stressor, leading to an initial sympathetic response. However, as individuals adapt and the practice becomes routine, the body may undergo a process of acclimatization. Over time, the sympathetic tone may decrease, and the parasympathetic tone could increase, reflecting a more relaxed and balanced autonomic state. This adaptation aligns with existing literature that suggests long-term regular practice of slow deep breathing is associated with enhanced parasympathetic activity.[22]The body's ability to adapt and modulate its autonomic responses based on the regularity and duration of a specific practice is a complex interplay, and individual variations in responses may also be influenced by factors such as baseline autonomic tone, psychological factors, and overall health status. This nuanced understanding adds depth to the interpretation of your study's results and highlights the importance of considering the temporal aspect of interventions when assessing their effects on the autonomic nervous system.

Conclusion

Your study's objective to evaluate the immediate effects of short-duration slow deep breathing on heart rate and blood pressure in healthy young adults is commendable. The observed decline in heart rate and blood pressure aligns with the broader understanding that slow deep breathing can lead to improvements in autonomic functions.Your interpretation of the results, attributing the observed changes to a decrease in sympathetic activity and an increase in parasympathetic activity, resonates with the well-established understanding of the autonomic nervous system dynamics. The shift towards parasympathetic dominance is often associated with a more relaxed and balanced physiological state, promoting a state of calmness and well-being.The conclusion drawn from your study, suggesting that practicing slow deep breathing for just 5 minutes can contribute to improving the autonomic nervous system balance in favor of parasympathetic dominance, underscores the potential of brief interventions for immediate physiological benefits. This insight is particularly relevant in the context of stress management and overall cardiovascular health, offering a practical and time-efficient approach for individuals seeking methods to enhance their well-being.Your study adds valuable evidence to the existing literature on the immediate effects of slow deep breathing, contributing to our understanding of the rapid autonomic responses to short-duration interventions.

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