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Lunar Breath and Heart's Rhythm: Chandra Nadi Pranayama and HRV in Healthy Young Adults

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ABSTRACT

Background

Traditionally, Chandra Nadi Pranayama (CNP), a type of left-nostril breathing, has been thought to promote parasympathetic activity and have soothing effects. However, there is a lack of scientific data defining its acute effect on autonomic regulation. Lunar energy is related to cooling and healing effects on the body and mind in ancient yogic writings that describe left-nostril breathing. Modern physiology suggests that unilateral nostril breathing may influence cerebral hemisphere activity and autonomic nervous system function differently on the basis of the nostril used.

Methods

This prospective cross-sectional study was conducted on 30 medical students aged 18–30 years who voluntarily participated and met the inclusion criteria. After Institutional Ethics Committee approval and written informed consent were obtained, heart rate variability was recorded via a digital 3-channel physiograph. ECGs in lead II were recorded continuously in three 5-minute phases: pre-CNP (baseline), during CNP, and post-CNP. CNP was performed under the guidance of a certified yoga instructor at a regulated pace of six breaths per minute. The HRV parameters were analyzed via standard time- and frequency-domain methods. Statistical analysis was performed via paired t tests, ANOVA and Games–Howell post-hoc via JAMOVI software.

Results

After CNP, the SDNN significantly increased (from 46.25 ± 16.59 to 54.72 ± 20.79; p = 0.01). During and after CNP, there were variations in RMSSD and NN50, although these variations were not statistically significant. VLF% significantly increased in the frequency domain after the CNP. While HF% demonstrated a significant post-CNP decline in comparison with both baseline and during-practice values, LF% increased during CNP and then declined significantly thereafter ($p < 0.05$). Although it was not statistically significant, the LF/HF ratio decreased during CNP.

Conclusion

Acute autonomic function was altered by a brief Chandra Nadi Pranayama session, as shown by increased parasympathetic activity after the intervention. These findings suggest that CNP could be a helpful nonpharmacological approach for medical students to foster autonomic balance and psychological resilience.

Keywords: Chandra Nadi Pranayama, Autonomic Nervous System, Medical Students, Left Nostril Breathing, Parasympathetic Activity.

INTRODUCTION

Yoga is a way of life described by Patanjali in his work “Patanjali yoga sutras”. Here, eight limbs of yoga are described: Yama, Niyama, Asana, Pranayama, Pratyahara, Dharana, Dhyana, and Samadhi.[1] Each limb paves the way for optimizing one’s body to start functioning efficiently at both the physical and mental levels. Studies have shown that the regular practice of yoga has helped individuals improve their quality of life and overcome stress.[2]

Pranayama is a simple yet powerful technique present from ancient times that can have a predominant impact on the well-being of an individual.[3] There are various types of pranayama that mainly regulate the type of breathing.[4] Pranayama affects the respiratory system and can be controlled voluntarily and involuntarily, which in turn can influence the cognitive functions of an individual.[5]

Owing to traditional yogic philosophy, right-nostril breathing (Surya Nadi Pranayama-SNP) is seen as invigorating and energizing, whereas left-nostril breathing (Chandra Nadi Pranayama-CNP) is said to have a cooling and relaxing impact on the body.[6] Nadisuddhi Pranayama, also known as alternate-nostril breathing, combines the two methods in a rhythmic way and is said to support physiological equilibrium.[7] By striking a balance between the sympathetic activation linked to right-nostril breathing and the parasympathetic influence of left-nostril breathing, this harmonizing technique is believed to regulate autonomic nervous system activity.[8]

The practice of CNP, also known as the "Lunar Breath" in yogic tradition, entails deliberate breathing through the left nostril. It is thought to activate the Ida Nadi, which is linked to parasympathetic, cooling, and calming processes, thereby fostering mental peace and autonomic balance. CNP is said to affect the autonomic status of an individual.[9] Researchers have reported that pranayama might enhance cardiorespiratory coupling, improve baroreflex sensitivity, and affect the brainstem cardiorespiratory center. It could also alter ventricular performance by reducing sympathetic activity and increasing parasympathetic activity.[5]

Medical students are said to be under stress, which could be attributed to their modern-day lifestyle, ability to cope with the curriculum, peer groups, extracurricular activities, etc. CNP for such students may prove beneficial, as CNP shifts the autonomic balance toward parasympathetic activity and therefore may instill calmness in them. This may help the students in their overall performance as well as their well-being.

Heart rate variability (HRV) is a useful mode for assessing the autonomic status of an individual. Studies have shown an increase in baseline parasympathetic tone in individuals practicing yoga regularly.[10] CNP has also been shown to have a beneficial effect on hypertensive patients.[9] Therefore, in this study, we intend to quantify the immediate change in autonomic balance that is induced by practicing CNP.

MATERIALS AND METHODS

Study design

This was a prospective cross-sectional study.

Participants

Thirty medical students between the ages of 18 and 30 years who were interested in taking part were recruited for the research. Individuals with fever, cough, vomiting, or other conditions that interfered with their day-to-day activities were excluded, as were those who regularly smoked, drank alcohol, or had a medical history of hypertension, diabetes, or thyroid problems; individuals who were taking antidepressants, antipsychotics, or psychotropic drugs; or those who suffered from sleep disorders or disturbances.

Ethical considerations

Clearance was obtained from the Institutional Ethics Committee (MTMC/IEC/2023/09). Informed consent was given in writing before participation by individuals who met the inclusion and exclusion criteria.

Intervention

A certified yoga trainer instructed and guided the participants with CNP. The participants were asked to sit comfortably. They were asked to close the right nostril gently using their thumb. Next, the participants performed pranayama through the open left nostril, emphasizing steady, calm breathing and deliberately employing the lower, middle, and upper lungs on each breath in a sequential manner. Using a stopwatch, the instructor timed each subject's inhalation and exhalation to ensure a consistent count of five. For more than five minutes, the instructor kept the pace of six breaths per minute (BPM) constant while the students completed the twenty-seven CNP rounds.[9]

Data Collection

The participants were asked to report to the department at 8 am after eight hours of sleep. They were instructed not to consume any beverages before the recording. The recording procedure was explained to the subjects. Basic personal information was collected, followed by measurements of height in cm and weight in kg, and body mass index was calculated via the formula BMI=kg/m^2.

HRV recording. The subjects were made to sit comfortably and allowed to stabilize for 10 minutes; meanwhile, the electrodes of the RMS 3-channel Digital Physiograph were hooked onto the subjects to record the ECG in lead II. Five minutes of baseline ECG data from lead II recordings were collected, after which the subject was guided to practice CNP under the guidance of a certified yoga instructor for five minutes. The recording was continued for five more minutes after the completion of practice. A digital ECG in lead II recording of a total of fifteen minutes was obtained, and HRV analysis was performed in blocks of five minutes consisting of pre, during-, and post practice CNPs and HRVs, which were subsequently obtained and analyzed.

Statistical Analysis

The statistical analysis was performed via JAMOVI software version 2.7.2.0. The data obtained were tabulated in an Excel sheet. The means and standard deviations for all the parameters were calculated. The pre- and during CNP, during and Post CNP, Pre and post CNP-HRV data were assessed via Student's t test. Also, ANOVA was done for pre, during and post CNP-HRV data followed by Games–Howell post-hoc test. Figure 1 shows the summary of the methodology of this study.

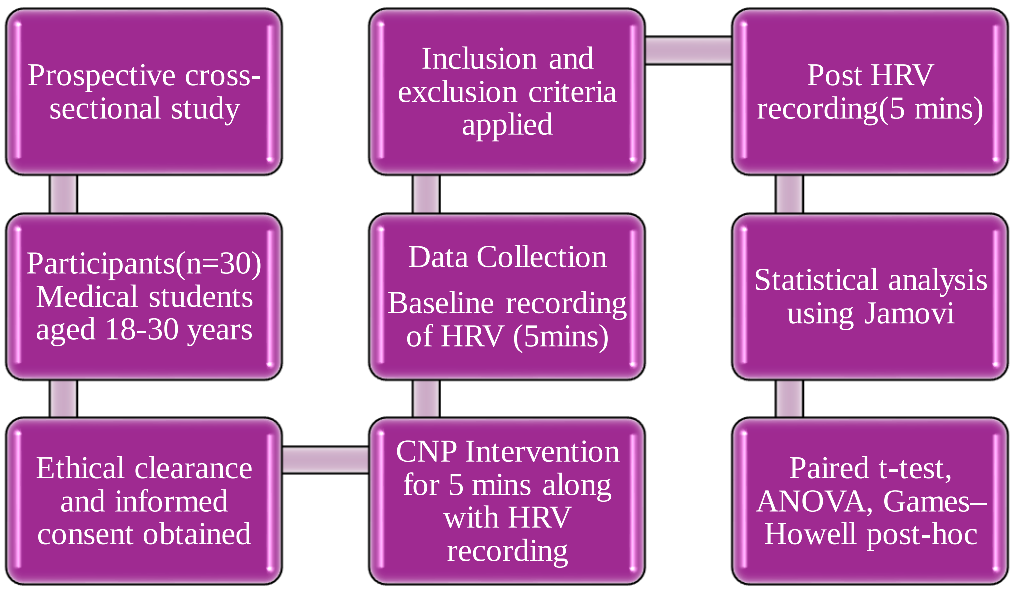

Figure 1: Summary of Methodology

RESULTS

Variation in the time domain parameters Pre, during and Post CNP (Table 1)

	Pre CNP		**CNP**		**Post CNP**		Paired t Test	Paired t Test	Paired t- Test
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Pre Vs Post**	**Pre Vs CNP**	**CNP Vs Post**
SDNN ms	46.25	16.59	50.45	21.86	54.72	20.79	**0.01***	0.21	0.20
RMSSD	35.41	15.62	38.75	16.30	34.59	14.86	0.51	0.23	0.14
NN50	52.80	47.22	50.83	43.12	54.73	42.74	0.73	0.79	0.36

Table 1: Changes in the time domain parameters with the application of the CNP

*p value <0.05 is considered statistically significant

The mean SDNN value showed a progressive increase from the pre- to the during- and post-CNP phases. Notably, the increase in the SDNN from 46.25 ± 16.59 to 54.72 ± 20.79 following CNP was statistically significant (p = 0.01). During CNP, the mean RMSSD value increased from 35.41 at baseline to 38.75 and then decreased to 34.59 after CNP. Nevertheless, neither the rise during the practice nor the fall following it were statistically significant. The mean NN50 value increased to 54.73 post-CNP after declining from 52.80 to 50.83 during CNP, but neither change was statistically significant.

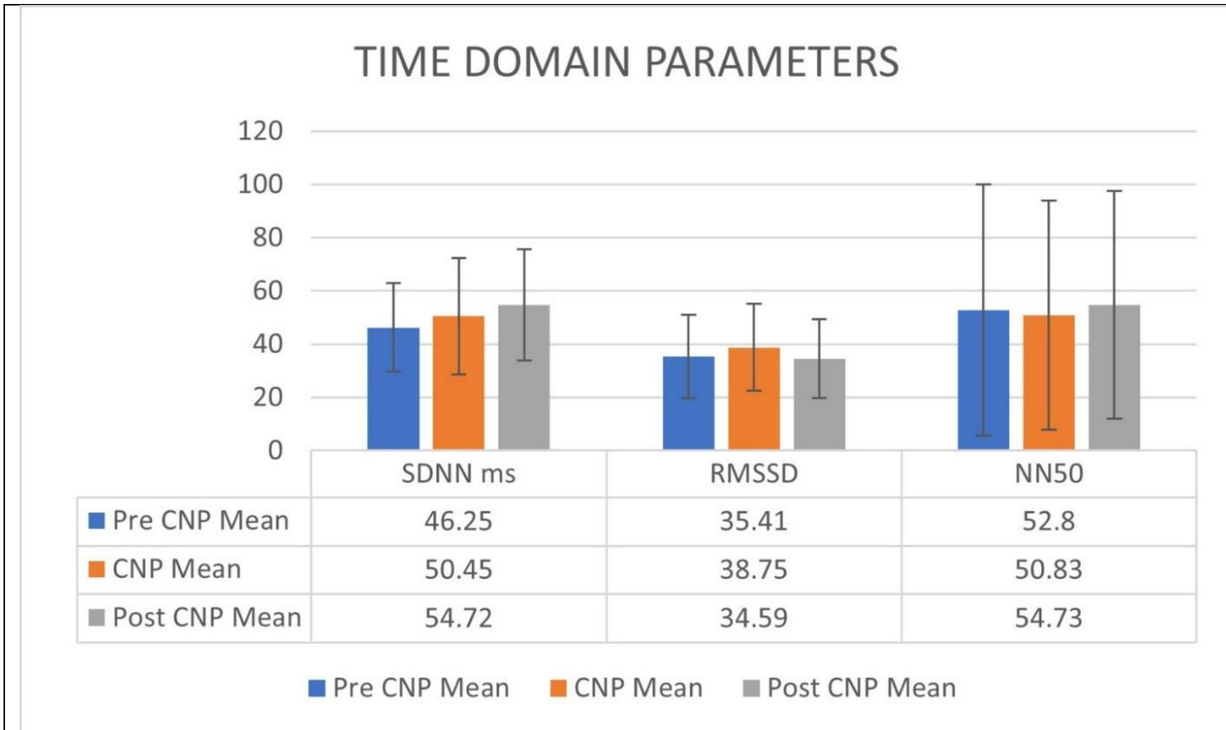

Figure 2: Comparison of the time domain parameters Pre, during and Post CNP

Variations in the frequency domain parameters Pre, during and Post-CNP (Table 2).

	Pre CNP		**CNP**		**Post CNP**		Paired t- Test	Paired t- Test	Paired t Test
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Pre Vs Post**	**Pre Vs CNP**	**CNP Vs Post**
VLF %	45.22	24.61	36.57	25.20	57.28	23.10	**0.03***	0.13	**0.00***
LF%	29.00	14.92	36.38	19.66	24.39	13.62	0.18	0.10	**0.01***
HF%	25.78	18.38	28.17	17.08	18.31	12.57	**0.03***	0.52	**0.00***
LF/HF	3.46	9.78	1.76	1.11	1.84	0.96	0.39	0.36	0.72

Table 2: Changes in frequency domain parameters in the context of the CNP

*p value <0.05 is considered statistically significant

During the CNP, the mean value of the very low frequency (VLF%) component decreased from a baseline value of 45.22 to 36.57 and then increased to 57.28 just after practice. This increase was statistically significant after CNP. Additionally, a statistically significant difference between the pre- and post-CNP VLF% values was found via paired t tests, suggesting a significant change in nonneuronal autonomic regulation after practice.

During CNP, the mean low-frequency (LF%) values rose from 29.00 at baseline to 36.38, and then, immediately after practice, they decreased to 24.39. The paired t test results for the CNP and post-CNP values were statistically significant. The mean high-frequency (HF%) values also increased from 25.78 at baseline to 28.17 during CNP before sharply declining to 18.31 after CNP. There were statistically significant differences between the pre- and post-CNP comparisons and between the CNP and post-CNP comparisons. A decrease in sympathetic dominance was indicated by the LF/HF ratio, which decreased from a baseline value of 3.46 to 1.76 during CNP and then slightly increased to 1.84 after CNP. However, none of the paired comparisons involving the LF/HF ratio reached statistical significance.

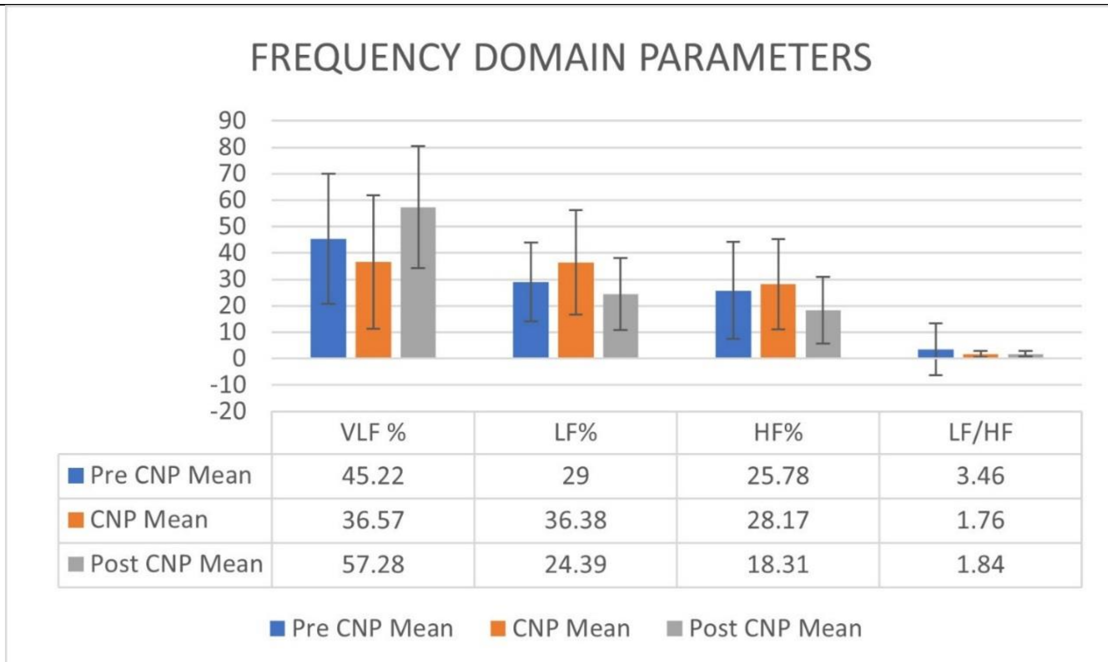

Figure 3: Comparison of the frequency domain parameters Pre, During and Post CNP

Time domain and frequency domain parameters	F	df1	df2	p Value
SDNN	1.4716	2	57.1	0.238
RMSSD	0.5553	2	57.9	0.577
NN50	0.0591	2	57.9	0.943
PNN50	0.2418	2	57.9	0.786
LF%	3.6255	2	56.9	**0.033***
HF%	3.6177	2	56.3	**0.033***
VLF%	5.3686	2	57.9	**0.007***
LF/HF	0.4468	2	51.4	0.642

Table 3: Comparison of HRV Parameters Across Pre-, During, and Post-CNP Phases Using Welch's One-Way ANOVA

*p value <0.05 is considered statistically significant

A one-way Welch ANOVA (Table: 3) showed significant differences across pre-CNP, CNP, and post-CNP intervention only for LF% (F=3.63, p=0.033), HF% (F=3.62, p=0.033), and VLF% (F=5.37, p=0.007).

SDNN, RMSSD, NN50, pNN50, variance, and LF/HF all had p>0.05, indicating no statistically significant overall change across the three phases.

LF power: Mean LF% increased from pre-CNP (29.0) to CNP (36.4) and then decreased to 24.4 post-CNP, with the post-CNP value being numerically lower than pre-CNP, suggesting a transient rise during practice followed by reduction below baseline.

HF power: Mean HF% rose slightly from pre-CNP (25.8) to CNP (28.2) and then dropped to 18.3 post-CNP, again suggesting a transient increase during practice with a fall below baseline afterward.

VLF power: Mean VLF% decreased from pre-CNP (45.2) to CNP (36.6) and then increased markedly to 57.3 post-CNP, indicating suppression during practice and a rebound to higher-than-baseline levels afterward.

HRV Parameter	ANOVA p-value	Post-hoc Pairwise Comparisons (p-value)	Direction & Interpretation
LF%	0.033	During CNP v. post-CNP: (0.025*)	LF power increased during CNP and decreased post-CNP, and the change was significant.
HF%	0.033	During CNP vs. Post-CNP: (0.040*)	HF power increased during CNP and decreased post-CNP, and change was significant
VLF%	0.007	During CNP vs. post-CNP: (0.005*)	VLF power decreased during CNP and increased post-CNP, and change was significant

Table 4: Games-Howell Post-hoc test of HRV Parameters Across Pre-, During, and Post-CNP Phases

*p value <0.05 is considered statistically significant

Games–Howell post-hoc analysis (Table 4) showed the only statistically significant pairwise differences for the frequency-domain variables to be between the “CNP” and “post-CNP” phases for LF% (mean difference 11.99, p=0.025), HF (mean difference 9.86, p=0.040), and VLF (mean difference −20.7, p=0.005).

No pre-vs-during or pre-vs-post comparison reached significance for any variable, including LF%, HF%, and VLF%, suggesting that the main detectable change is the shift from the “CNP” state to the “post-CNP” state rather than a clear pre-CNP to post-CNP effect.

The acute effect of CNP is characterized as a significant redistribution of spectral power among LF%, HF%, and VLF% when comparing the “CNP” state with the “post-CNP” state, without clear, statistically significant pre-CNP to post-CNP changes in standard time-domain parameters of HRV.

DISCUSSION

This study intended to quantify the immediate change in autonomic balance that is induced by practicing CNP. Notably, after practicing CNP, the mean standard deviation of NN intervals (SDNN), a global indicator of overall HRV and autonomic flexibility, significantly increased. This result implies a change toward parasympathetic predominance and an improvement in autonomic flexibility immediately after the intervention as seen in Table 1 and figure 2. Even a short period of left-nostril breathing may help promote autonomic recovery and cardiovascular stability because increased SDNN is generally linked to better vagal modulation and less physiological stress.[11] This improvement in autonomic balance suggests a possible protective effect of CNP against mental stress, thereby bolstering frontal brain processes that are involved in cognitive control and emotional regulation.[12]

The nonsignificant variations in the NN50 and RMSSD suggest a brief, transitory alteration in parasympathetic activity both during and after CNP. The commonly used indicators of parasympathetic nervous system activity are the RMSSD and NN50. An initial rise in RMSSD during CNP may be the result of increased vagal tone caused by slow parasympathetic activation-related, regulated breathing connected to left nostril dominance. Several studies are in line with this finding following CNP.[9,13] After CNP, the subsequent decline may indicate a return to baseline autonomic tone when the breathing pattern's initial effects subside. Similarly, the slight decrease in NN50 during CNP followed by a rebound may indicate a delayed parasympathetic rebound effect or individual variability.

The practice of left nostril yoga breathing (CNP) is related to a nonsignificant modulation of parasympathetic activity, as shown by the temporary increase in the RMSSD during practice and a rebound in the NN50 post practice. However, instead of a noticeable change in vagal tone, these results point to a minor autonomic adjustment. The present study revealed no statistically significant changes in short-term HRV indices (RMSSD and NN50), despite prior research showing significant decreases in systolic and mean arterial pressure as well as changes in sympathetic subdivisions after left nostril breathing.[7] This suggests that brief CNP practice may have mild autonomic effects without noticeable cardiovascular changes. Studies that have shown increased vagal modulation after several weeks of pranayama or alternate nostril breathing techniques suggest that longer or more prolonged practices may be required to produce significant variations in these parameters.

The very low frequency (VLF) components of heart rate variability (HRV) in short-term HRV studies can still provide valuable information, even though they usually yield meaningful insights in long-term recordings (over 24 hours). Slower regulatory processes, such as thermoregulation, the renin–angiotensin system, hormone modulation, and diurnal variation, are believed to be reflected in these very low-frequency components.[14] In the present study, even though the recording period was brief, a significant increase in VLF% was noted just after the CNP practice as seen in table 2 and figure 3. This observation points to an acute activation of these slower-acting physiological mechanisms, which may be caused by improved parasympathetic regulation and systemic relaxation caused by breathing through the left nostril.

The observed significant increase in the VLF% after CNP in this study can also be attributed to augmented regulatory activity associated with emotional adaptation.[15] While the rebound increase after CNP may indicate a compensatory adjustment or a delayed autonomic response related to restoration and homeostasis, the initial decrease in VLF% during practice may suggest temporary suppression of sympathetic activity. Laborde et al. (2017) reported similar results, emphasizing the link between improved emotional regulation during mindfulness and relaxation therapies and increased VLF power.[16]

LF% and HF% variations before and after CNP show that autonomic function is dynamically modulated in response to left-nostril breathing. The notable increase in LF% during exercise could be the result of heightened sympathetic modulation or a brief increase in sympathetic activity, potentially due to initial focus and alertness induced by the breathing process. Nonetheless, the subsequent significant decrease in LF% following CNP indicates a reduction in sympathetic drive, which is consistent with the relaxing and restorative benefits typically attributed to left-nostril breathing. This pattern shows sympathetic withdrawal immediately following practice. A study by Kumar C et al. (2015) revealed a similar pattern of significant decreases in LF% immediately following CNP.[17]

Additionally, increased vagal (parasympathetic) activity, which is frequently linked to slow and focused breathing techniques, is reflected in the observed increase in HF% during CNP. The notable decrease in HF% following CNP may indicate a return to normal vagal tone owing to the acute effect of controlled breathing waves. Interindividual variability may have contributed to the lack of statistical significance in the changes, even though the LF/HF ratio decreased during CNP and remained below baseline after CNP. However, this pattern favors a decrease in sympathetic–parasympathetic imbalance, which could enhance autonomic resilience and aid in recovery from stress. A significant increase in HF% has been documented in a number of studies just after various pranayama techniques were completed.[18-20] Nevertheless, there is currently inadequate information that particularly addresses the instantaneous changes in HF% after CNP.

Using Welch's one-way ANOVA to account for unequal variances, the current study assessed acute autonomic changes throughout the pre-CNP, during-CNP, and post-CNP phases. In the current study, only the frequency-domain parameters (LF%, HF%, and VLF%) as shown in table 3, changed significantly, but time-domain indices (SDNN, RMSSD, NN50, and pNN50) did not change statistically significantly during the course of the three phases. This indicates that although the overall beat-to-beat variability may be maintained, the dynamic interplay of sympathetic and parasympathetic influences is significantly altered as seen in a study by Bari et al. (2019).[21] Also, this discrepancy highlights the need for a thorough spectral analysis to fully capture the adaptive responses of the autonomic nervous system, since time-domain measurements might not accurately capture the complex rebalancing of sympathetic and parasympathetic tones during acute physiological stressors. In particular, the notable changes in LF%, HF%, and VLF% indicate that vascular tone and central volume regulation are dynamically modified during CNP, impacting the oscillatory patterns of cardiovascular control as seen in a study by Kiselev et al., 2020.[22] This is consistent with research by Soares et al. (2005) in other surgical settings, where frequency-domain analysis offers more nuanced insights into the relative contributions of sympathetic and parasympathetic branches to heart rate variability, especially with regard to sympathovagal balance and vagal modulation.[23] According to a study by Kiselev et al., 2020, the observed changes in spectral components-more especially, the rise in VLF% and shifts in LF% and HF%-indicate a complex interplay of regulatory mechanisms that go beyond simple sympathetic activation/deactivation or parasympathetic predominance/withdrawal. These changes may be related to changes in thermoregulation, renin-angiotensin system activity, or other slow oscillatory rhythms.[22]

The nature of these autonomic alterations was further elucidated by post-hoc comparisons using the Games–Howell test. For LF%, HF%, and VLF%, the only pairwise differences that were statistically significant were between the "during-CNP" and "post-CNP" phases. These results in the current study demonstrate that, rather than occurring between the baseline and practice phases, the most noticeable autonomic change occurs right after the practice is stopped. LF power increased during CNP and decreased post-CNP, and the change was significant. HF power increased during CNP and decreased post-CNP, and change was significant. VLF power decreased during CNP and increased post-CNP, and change was significant. This implies that although the practice itself produces a specific autonomic state, a distinct and potentially compensatory re-calibration of sympathetic and parasympathetic balance occurs during the recovery phase right after cessation.[24] A dynamic autonomic readjustment is highlighted by the observed significant fluctuations in frequency-domain parameters, especially the rebound of VLF% above baseline post-CNP and the decrease in LF% and HF% below baseline. These fluctuations may indicate a shift towards parasympathetic dominance or altered thermoregulatory and vasomotor influences. Changes in frequency-domain HRV values, which demonstrate the intricate interaction between sympathetic and parasympathetic activity, point to a complicated physiological response to CNP rather than a straightforward shift towards one system (Duan et al., 2024) (Telles et al., 2011).[25,26] This is corroborated by findings in various meditation techniques, where autonomic changes can involve intricate sympathetic–parasympathetic interactions rather than just a simple rise in parasympathetic activity (Borah et al., 2023).[27] For example, both LF power and HF power may rise during specific meditative states, suggesting that both autonomic nervous system branches are activated simultaneously, possibly with a sympathetic dominance.[28] Further study is necessary to completely describe the long-term trajectory of these autonomic changes and their therapeutic importance, possibly requiring longer monitoring periods beyond the immediate post-CNP phase.

CONCLUSION

The results of this study show that CNP can acutely modulate autonomic function in a single session, as shown by notable alterations in heart rate variability time and frequency domain characteristics. Improved autonomic balance and increased parasympathetic activity are suggested by the observed increase in SDNN and the postpractice shift in VLF% and LF%. These results demonstrate how CNP may be used as a simple nonpharmacological method to support stress resilience and autonomic control. Long-term follow-up and larger, more diverse populations are needed for future studies to validate and build on these effects.

Limitations

There are various limitations to this investigation. The results may not be as generalizable to other groups because of the small sample size and restriction to undergraduate medical students in a particular age bracket. Furthermore, long-term or sustained autonomic changes were not evaluated; instead, only the acute effects of a single Chandra Nadi Pranayama session were evaluated. Variations in individual breathing patterns may have affected the results, and psychological factors such as baseline anxiety or stress levels were not taken into consideration. Furthermore, identifying the precise effects of CNP when there is no control or placebo group present is more difficult. Future research can address these gaps by analyzing both short- and long-term impacts while accounting for behavioral and psychological factors, using randomized controlled trial designs with suitable control groups, and using a larger, more diverse population.

Statements and Declarations

Conflict of Interest

The authors declare that they have no competing interests
Authors are responsible for the correctness of the statements provided in the manuscript.

Ethics Approval and Consent to Participate

The study was approved by the Institutional Ethics Committee (Approval No. MTMC/IEC/2023/09). Informed consent was obtained from all individual participants prior to their inclusion in the study.

Author Contributions

Ms. Khushi Mandal: Data acquisition, analysis, and interpretation, revised the draft, and approved the version to be published.
Dr. Vinay AV: Conception and design of the work, data acquisition, analysis, and interpretation drafted the work, and approved the version to be published.
Dr. Sindhu R: Data acquisition, analysis, and interpretation, revised the draft critically, and approved the version to be published.
Dr. Hirok Chakraborty: Data acquisition, analysis, and interpretation, revised the draft, and approved the version to be published.

All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Data Availability

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

Acknowledgement

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