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Effects of Swara Yoga-Based Nostril Breathing Techniques on Physiological Arousal Indicators in Adolescents: A Randomized Experimental Design

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ABSTRACT:

This study investigated the physiological effects of Swara Yoga-based nostril breathing techniques, Left Nostril Breathing (LNB), Right Nostril Breathing (RNB), and Alternate Nostril Breathing (ANB), on heart rate (HR), respiratory rate (RR), and skin conductance (SC) among 60 adolescents (13.65±1.79), randomly assigned to four groups (n = 15 each), including a control group (CG). For a 12-week intervention, participants practised their assigned technique daily for 15 minutes. One-way ANOVA revealed significant differences among groups in HR [F (3,56) = 9.354, p < .001], RR [F (3,56) = 22.953, p=0.001], and SC [F (3,56) =23.100, p=0.002]. Post-hoc analysis showed LNB significantly reduced HR compared to RNB (p<0.001) and CG (p=0.024), and lowered RR (p<0.001 vs. RNB; p<0.001 vs. CG) and SC (p<0.001 vs. all). RNB elevated all arousal markers, while ANB showed moderate reductions, notably in RR (p=0.001 vs. CG) and SC (p=0.030 vs. CG). These findings indicate LNB is most effective in reducing physiological arousal, offering potential as a non-pharmacological tool for adolescent stress regulation.

Keywords: *Swara Yoga, Nostril breathing, Heart Rate, Respiratory Rate, Skin Conductance, Adolescents, Physiological arousal*

1. Introduction:

Breath regulation practices from yogic traditions have gained attention for their physiological and psychological benefits (Saoji et al., 2019). One such practice, *Swara Yoga*, emphasizes nostril-specific breathing (ida, pingala, sushumna) to align with natural biorhythms and regulate internal energy (Muktibodhananda, 2004). This study investigates three key physiological arousal markers—Heart Rate (HR), Respiratory Rate (RR), and Skin Conductance (SC)—which reflect real-time autonomic nervous system (ANS) activity. HR varies with sympathetic and parasympathetic dominance (Berntson et al., 2007), RR responds to emotional states like anxiety (Homma & Masaoka, 2008), and SC indicates sympathetic arousal via sweat gland activity (Critchley, 2002). These non-invasive indicators are especially relevant for assessing adolescent physiology.

Swara Yoga techniques, such as Left Nostril Breathing (LNB/Chandrabhedi), Right Nostril Breathing (RNB/Suryabhedi), and Alternate Nostril Breathing (ANB/Nadi Shodhana), are believed to impact the ANS distinctly. LNB is associated with ida nadi and parasympathetic effects, RNB with pingala nadi and sympathetic activation, while ANB balances both. Although ANB has been studied for its autonomic balancing effects (Telles et al., 2013), LNB and RNB remain underexplored, particularly in adolescents. This age group often experiences emotional fluctuations and academic stress (Compas et al., 2017), making them a key demographic for non-pharmacological interventions.

This study evaluates the physiological effects of these three Swara Yoga breathing techniques compared to a no-intervention control group. By measuring HR, RR, and SC, the research aims to clarify how each pranayama modulates arousal and contributes to adolescent emotional regulation, offering insights into the scientific and practical value of Swara Yoga in health and education.

2. Materials and Methods:

2.1 Participants:

A total of sixty healthy adolescents, aged between 12 to 17 years with a mean and SD (13.65 ± 1.79), comprising both males and females, were selected from a higher secondary school in Gwalior, India. These participants were randomly divided into four groups, each consisting of 15 individuals: Left

Nostril Breathing (LNB), Right Nostril Breathing (RNB), Alternate Nostril Breathing (ANB), and a control group (CG). Consent from parents and approval from the school were secured before the study.

2.2 Intervention:

For 12 weeks, participants engaged in their designated breathing techniques for 15 minutes each day under supervision. The first experimental group practised the Left Nostril Breathing Technique, while the second and third groups practised the Right Nostril Breathing Technique and the Alternate Nostril Breathing Technique, respectively. The control group did not participate in any breathing exercises.

2.3 Variables of the Study:

Based on the theoretical principles of Swara Yoga and supported by relevant research, three primary dependent variables were identified: Heart Rate (HR), Respiratory Rate (RR), and Skin Conductance (SC). These variables were selected for their proven sensitivity in indicating responses of the autonomic nervous system and physiological arousal during breath regulation practices. The independent variable was the specific nostril breathing technique employed: Left Nostril Breathing (LNB), Right Nostril Breathing (RNB), Alternate Nostril Breathing (ANB), or no intervention (Control Group).

2.4 Study Design:

This research utilised a pre-test, post-test, randomised controlled design involving sixty adolescents attending school. Participants were randomly divided into four groups, each comprising fifteen students: three experimental groups and one control group.

The intervention spanned twelve weeks, with supervised sessions occurring five days a week. Each session lasted around 15 minutes, which included 5 minutes for preparatory settling and 10 minutes dedicated to guided nostril-specific breathing exercises. Baseline and post-intervention measurements of heart rate (HR), respiratory rate (RR), and skin conductance (SC) were taken for all groups to assess the relative effects of the breathing techniques.

2.5 Administration of Tests:

Participants were instructed to sit quietly and comfortably with their eyes closed to facilitate relaxation and minimise movement. Testing was conducted in a quiet, controlled environment to reduce external influences on physiological measurements. Before the assessments, demographic information, including name, age, gender, height, and weight, was collected. Physiological variables: Heart Rate (HR), Respiratory Rate (RR), and Skin Conductance (SC) were measured using a reliable Medicaid Biofeedback machine. Specifically, the HRV Sensor was used to assess HR in beats per minute, the Respiration Sensor measured RR in breaths per minute, and the SC-Flex/Pro Sensor recorded SC in micro-Siemens (μS). Data collection took place both before and after the twelve-week intervention, with consistent environmental and procedural conditions maintained throughout to ensure reliability and minimise variability.

2.4 Statistical Analysis:

A one-way ANOVA was conducted independently to analyse the data and assess the presence of statistically significant differences among the groups. To investigate pairwise differences further, Bonferroni-adjusted post hoc tests were utilised. All statistical analyses were conducted using SPSS version 24, with a significance level established at 0.05 (5%).

Results: ***Table 2*** displays the descriptive statistics for physiological variables, including heart rate, respiratory rate, and skin conductance, across various nostril breathing groups: Left Nostril Breathing (LNB), Right Nostril Breathing (RNB), Alternate Nostril Breathing (ANB), and Control Group (CG).

Table 1: Descriptive Statistics of Physiological Variables in Different Nostril Breathing Techniques

Variables	Treatment Groups	N	Mean	S. D.	Std. Error
Heart Rate	LNB	15	73.06	6.88	1.77
	RNB	15	86.86	7.39	1.90
	ANB	15	79.00	6.54	1.69
	CG	15	80.80	7.88	2.03
Respiratory Rate	LNB	15	11.26	1.22	0.31
	RNB	15	16.33	2.60	0.67
	ANB	15	12.06	1.66	0.43

	CG	15	15.06	2.01	0.52
Skin Conductance	LNB	15	3.13	1.30	0.33
	RNB	15	5.73	1.16	0.30
	ANB	15	7.13	1.35	0.35
	CG	15	5.73	1.53	0.39

Heart Rate: The LNB group exhibited the lowest average heart rate, with a mean and SD of 73.07 ± 6.88, respectively, while the RNB group recorded the highest average heart rate, with a mean and SD, 86.87±7.40. The ANB and CG groups presented intermediate values, with mean and SD, 79.00±6.55 and 80.80 ±7.88, respectively.

Respiratory Rate: The LNB group had the lowest respiratory rate, with a mean and SD of 11.27±1.22, respectively, whereas the RNB group showed the highest respiratory rate, with a mean of 16.33 and an SD of 2.61. The ANB group had a mean and SD of 12.07±1.67, while the CG group fell in between with a mean and SD of 15.07±2.02.

Skin Conductance: The LNB group recorded the lowest skin conductance, with a mean and SD of 3.13±1.30, while the ANB group had the highest skin conductance, with a mean and SD of 7.13±1.36. Both the RNB and CG groups had the same mean (M = 5.73), though their standard deviations differed slightly (SD = 1.16 and 1.53, respectively).

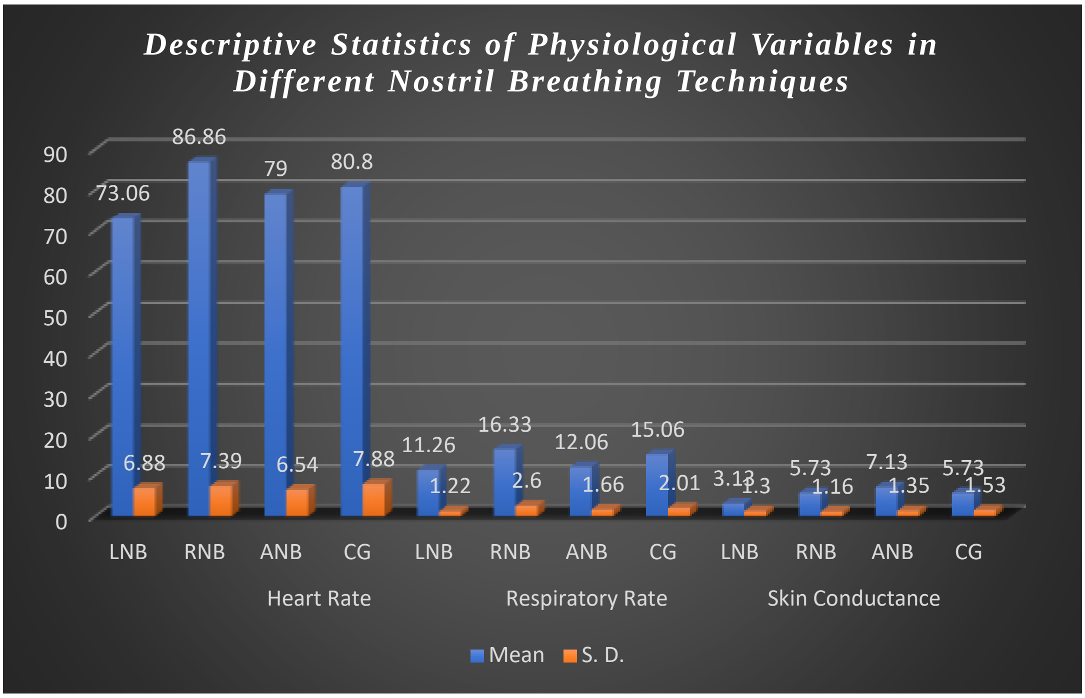

Figure 1: Graph showing Descriptive Statistics of Physiological Variables in Different Nostril Breathing Techniques

Table 3 illustrates that an Independent one-way ANOVA was performed to assess the impact of various nostril breathing techniques on different physiological variables. A statistically significant difference was found in the effects of these techniques ($p<0.05$) on Heart Rate [$F(3, 56) = 9.354$, $p < .05$], Respiratory Rate [$F(3, 56) = 22.953$, $p < .05$], and Skin Conductance [$F(3, 56) = 23.100$, $p < .05$], except the Control Group. Additionally, a post-hoc analysis was conducted to identify the most effective technique.

Table 3 F-table for Testing Significance of Different Nostril Breathing Groups (Between-Subject)

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
HR	Between Groups	1452.667	3	484.222	9.354	**.000***
RR	Between Groups	260.850	3	86.950	22.953	**.001***
SC	Between Groups	125.400	3	41.800	23.100	**.002***

***The level of significance was set at 0.05**

To investigate group differences in greater detail, Bonferroni-adjusted post hoc pairwise comparisons were performed for heart rate, respiratory rate, and skin conductance as shown in ***Table 4***. The results indicated that participants in the Left Nostril Breathing (LNB) group had significantly ***lower heart rate*** values than those in the Right Nostril Breathing (RNB) group ($p<0.001$) and the control group (CG) ($p=0.024$). Furthermore, the RNB group demonstrated a significantly higher heart rate compared to the Alternate Nostril Breathing (ANB) group ($p=0.021$). However, no statistically significant difference in heart rate was found between the ANB and CG groups. In terms of **Respiratory Rate**, the LNB group exhibited significantly lower rates compared to both the RNB group ($p<0.001$) and the control group (CG) ($p< 0.001$), indicating a substantial calming effect. Conversely, the RNB group demonstrated significantly higher respiratory rates than the ANB group ($p<0.001$). Additionally, the ANB group recorded significantly lower respiratory rates than the control group ($p=0.001$). Regarding **Skin Conductance**, participants in the LNB group again displayed significantly lower values compared to those in the RNB group ($p<0.001$), the ANB group ($p<0.001$), and the control group ($p<0.001$), indicating a reduced level of physiological arousal. The ANB group also showed significantly higher skin conductance than both the RNB and control groups ($p=0.030$ for both comparisons). Overall, these findings suggest that LNB is the most effective breathing technique for reducing indicators of physiological arousal, including heart rate, respiratory rate, and skin conductance. In contrast, RNB seemed to elevate arousal across all three measures, while ANB demonstrated moderate effects, particularly in lowering respiratory rate and maintaining intermediate levels of skin conductance and heart rate.

Table 4 Pairwise Comparison of Marginal Means of Different Nostril Breathing Groups in Heart Rate, Respiratory Rate, and Skin Conductance.

Dependent Variables	**Treatment Group**	**Treatment Group**	**Mean Difference**	**Std. Error**	**Sig.**
Heart Rate	**LNB**	**RNB**	-13.80	2.62	**.000***
		ANB	-5.93	2.62	.120
		CG	-7.73	2.62	**.024***
	RNB	LNB	13.80	2.62	.000
		ANB	7.86	2.62	**.021***
		CG	6.06	2.62	.108
	ANB	LNB	5.93	2.62	.120
		RNB	-7.86	2.62	.021
		CG	-1.80	2.62	.902
	CG	LNB	7.73	2.62	.024
		RNB	-6.06	2.62	.108
		ANB	1.80	2.62	.902
Respiratory Rate	**LNB**	**RNB**	-5.06	.71	**.000***
		ANB	-.80	.71	.675
		CG	-3.80	.71	**.000***
	RNB	LNB	5.07	.71	.000
		ANB	4.27	.71	**.000***
		CG	1.27	.71	.293
	ANB	LNB	.80	.71	.675
		RNB	-4.26	.71	.000
		CG	-3.00	.71	.001
	CG	LNB	3.80	.71	.000
		RNB	-1.26	.71	.293
		ANB	3.00	.71	.001
	LNB	**RNB**	-2.60	.49	**.000***

Skin Conductance		**ANB**	-4.00	.49	**.000***
		CG	-2.60	.49	**.000***
	RNB	LNB	2.60	.49	.000
		ANB	-1.40	.49	**.030***
		CG	.00	.49	1.000
	ANB	LNB	4.00	.49	.000
		RNB	1.40	.49	.030
		CG	1.40	.49	**.030***
	CG	LNB	2.60	.49	.000
		RNB	.00	.49	1.00
		ANB	-1.40	.49	.030

***The level of significance was set at 0.05**

4. Discussion of Results:

This study supports the hypothesis that nostril-specific breathing techniques produce distinct effects on autonomic arousal, in line with traditional Swara Yoga principles (Muktibodhananda, 2004). The findings highlight the practical relevance of breath modulation for managing physiological responses in adolescents, who often experience heightened stress and emotional reactivity (Compas et al., 2017). Left Nostril Breathing (LNB) consistently induced a parasympathetic shift, demonstrated by reductions in heart rate, respiratory rate, and skin conductance—indicators of enhanced vagal tone and relaxation (Saoji et al., 2019; Telles et al., 2013; Berntson et al., 2007; Critchley, 2002). In contrast, Right Nostril Breathing (RNB) led to elevated heart and respiratory rates and increased skin conductance, indicating sympathetic nervous system activation. This supports prior findings that RNB promotes physiological arousal and heightened alertness (Shannahoff-Khalsa, 1991; Telles & Desiraju, 1991). While less suited for stress reduction, RNB may be useful when increased engagement is desired. Alternate Nostril Breathing (ANB) showed mixed results—some participants experienced calming effects, others increased arousal—suggesting a balancing influence, consistent with research noting its regulatory effects on autonomic function (Pal et al., 2004). These outcomes underscore the value of LNB as a simple, non-pharmacological strategy for stress management in adolescents, while RNB and ANB offer context-dependent tools for enhancing alertness or maintaining autonomic balance.

5. Conclusion:

This study shows that Swara Yoga nostril breathing techniques significantly affect physiological arousal in adolescents, supporting traditional ideas of nostril dominance and autonomic control. Among the three practices, LNB, RNB, and ANB, LNB was most effective in promoting relaxation, with lower HR, RR, and SC, indicating parasympathetic activation. RNB increased all three markers, suggesting sympathetic arousal and potential use in boosting alertness. ANB produced moderate, balanced effects, pointing to its role in maintaining autonomic stability. Overall, the findings support Swara Yoga as a useful, non-pharmacological approach to stress management in adolescents.

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