IMMEDIATE EFFECT OF ALTERNATIVE NOSTRIL BREATHING ON COGNITIVE FUNCTION – A RANDOMIZED CONTROL STUDY

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ABSTRACT

Cognitive functioning deals with the intellectual activity that encompasses mental processes, such as attention, processing speed, learning and memory executive functions, verbal fluency, judgment and evaluation and working memory. Alternative nostril breathing or *Nadi-Shodana* pranayama is the key to bring about psychosomatic integration, optimizing human performance, overall well being and harmony. This study was designed to evaluate the immediate effect of alternative nostril breathing on cognitive function: attention, memory, learning, and autonomic variables: respiration, blood pressure, heart rate variables. A total of 60 eligible subjects who are new to yoga practice were recruited for this study after satisfying the inclusion and exclusion criteria and further randomized into two groups. The first group (n=30) comprised of yoga intervention, practiced alternative nostril breathing for 20 minutes and the second group (n=30) comprised of breath awareness, practiced breath awareness for 20minutes. Subjects across groups were assessed at the baseline (pre-intervention) and end point (post intervention). Data analysis was done using statistical analysis software. Significant results were observed in case group with respect to cognitive domains: attention questioner<0.001, RVLT<0.001, digit span memory<0.001, anxiety questioner <0.001and autonomic variables: Pulse rate, respiration rate, systolic blood pressure and diastolic blood pressure were decreased showing decrease in sympathetic activity and increase in parasympathetic activity when compared to the control group. Results of the present study showed, significant decrease in the mean HR, LF, LF/HF ratio and SBP and increase in the Mean RR, mean HR RMSSD, pNN50 and HF values in case group when compared to the control which indicates the sympathetic withdrawal with parasympathetic activation shifting the sympatho vagal balance towards parasympathetic dominance there by supporting practice of alternative nostril breathing. The results of the present study indicate the short-term practice of alternative nostril breathing or Nadi-Shodana pranayama induces parasympathetic dominance and improve cognitive function.

Index terms*: cognitive function, alternative nostril breathing, autonomic-variables.*

INTRODUCTION

Cognition is the mental process of acquiring knowledge and understanding through thought experience and the senses, it deals with the intellectual activity such as attention, processing speed, learning and memory executive functions, verbal fluency, judgment and evaluation and working memory.(1) Cognitive control process involves executive function which include attention, initiation, mental flexibility, organization, abstract thinking, planning and problem-solving.(2) The main aspects of cognitive functions are attention and memory, Focalization and concentration of consciousness are its essences. Cerebral cortical activation influences the ability to process information .States of cortical activation include arousal, alertness, vigilance, and attention.(3) Prefrontal cortex executive functions, such as working memory interact with limbic processes to foster impulse control. Such an interaction is referred to cognitive control, cognitive inhibition, and cognitive–emotion interaction. (4)

Attention has also been referred to as the allocation of limited processing resources. It plays an important role in every student category in their life and lack of attention is the main problem in most of the students. (5)Memory is related to the limbic system often understood as an information processing system with explicit/declarative and implicit /non-declarative functioning that is made up of a sensory processor. In Explicit function, memory is the

conscious storage and recollection of data. In implicit, memory is the unconsciousness storage and recollection of information.(6) Stress is stimulant and act as "the non-specific response of the body to the demand". Small amount of stress may bring out survival mechanism, too much stress can interfere equilibrium of an organism. Stress can interfere with student's preparation, concentration, and performance. (7)The physiological responses to physical stress or cognitive stress consist of adjustments in metabolism, cardiovascular function, and the autonomic nervous system.(8) Voluntarily regulated and Paced deep breathing technique includes changes in the rate, depth of respiration and emphasizes body awareness involving focus on one's attention on breathing practices and enhance a variety of cognitive functions(9,10) Alternative nostril breathing provides high-level evidence for positive outcomes for the autonomic nervous and cardiopulmonary systems. Stimulation of the cortex may activate the autonomic nervous system, resulting in changes in heart rate (HR) and blood pressure. Different stresses may induce different patterns of autonomic activity. (11, 12)

According to the archeological evidence, yoga originated in India as early as 3000 B.C, Yoga is an ancient discipline designed to bring balance and health to the physical, mental, emotional, and spiritual dimensions of the individual. (13)Pranayama is a part of *Astanga Yoga*. It is comprised of two roots: *Prana* and *Ayama*. *Prana* means vital energy or life force and ayama means to control and is used to denote various rules or codes of conduct. According to Maharshi Patanjali "*Tasminsati shwasaprashwasayorgativicchedaha pranayama''* (II Sutra 49). Pranayama is the regulation of the incoming and outgoing flow of breath with retention. (14) Yogic breathing is physiologically stimulating and can be described as a natural "technological" solution to optimize human performance which can be categorized into: cognitive function and physical performance. (11)

According to Patanjali yoga sutras, 'memory is an experienced object not being lost from the mind'. An alternative nostril breathing phenomenon is a consequence of alteration of the subtle energy in the *Ida* and *Pingala*. (15)Yoga influences the mind; pranayama brings about psychosomatic integrations, optimizing human performance and aims concerning mental function to improve the ability to maintain cognitive control, specifically in the areas of attention, memory, and arousal control. (16)The normal nasal cycle consists of alternating phases of congestion and decongestion of nasal, breathing alternately through each nostril helps to restore the autonomic nervous system balance. (17)Potential benefits of the regular practice of ANB include modulation of sympatho-vagal balance, improved cardiac function, refined metabolism, stress relief, increased cognitive acumen, and the attenuation of normal aging, among others .(11) An interaction between motor memory formation and consolidation and deep breathing practices appears highly likely. Learning and retention of motor skills is supported by a complex Neuro-anatomical architecture that includes dorso-lateral prefrontal cortex, posterior parietal cortex, and primary motor cortex, as well as subcortical structures such as basal ganglia and cerebellum(20)

METHODOLOGY

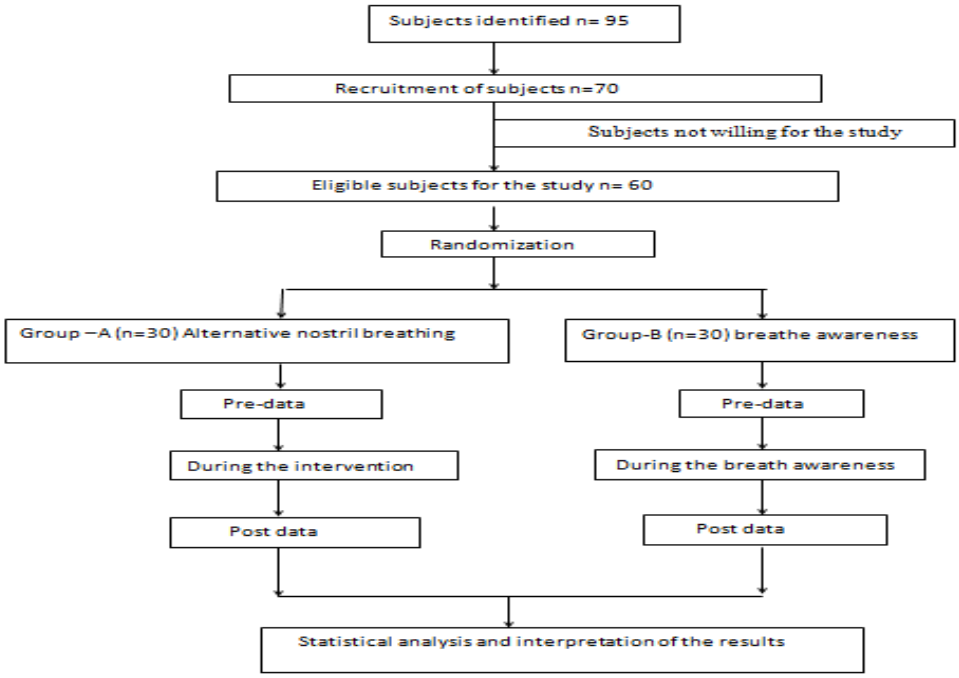
The study population was recruited from the Sri Dharmasthala Manjunatheshwara residential hostels, Ujire. After the initial screening, 95 subjects were identified, 70 subjects were recruited, for the study. The study is on healthy individuals no criteria for diagnosis is involved. Subjects were given information verbally regarding the intervention and assessment, later sheet consisting of the same of information was given to subject to go through and an opportunity was given to ask any question if aroused. Among the recruited 70 subjects, 10 subjects were not willing to continue for the study. Later 60 subjects were recruited based on selection criteria, and were asked to sign the informed consent form. The recruited subjects were randomly allocated into two groups using computer generated randomizer. Approval for the study was granted from the institutional ethical committee.

Inclusion criteria: They should be novices to the field of yoga. Age between 17-25 years (either gender).Healthy volunteers with no known existing medical conditions.Willing to Participate in the study by giving a signed consent form.

Exclusion criteria : Subjects under the influence of any psychoactive substances, sedatives anxiolytics, anti-depressants, Subjects with any co-morbid conditions like hypertension, diabetes mellitus, epilepsy, bronchial asthma, Female subjects during their menstrual cycle will not participate in the experiment as a menstrual cycle is known to influence the circulatory and hormonal dynamics.

Study Design: The study subjects who fulfilled the demands of inclusion and exclusion criteria were divided equally into two groups. Subject design is a randomized controlled trial.

Group A: (*n*=30) - Practice of alternative nostril breathing for 20 minutes in the evening.
Group B: (*n*=30) -Breath awareness for 20 minutes in the evening.



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Intervention:

Case group: The subjects were asked to sit in *sukha-asana* with spine in upright posture, adopting *nasagra mudra* in right hand and practice alternative nostril breathing or *Nadi shodana* pranayama for 20 minutes. Control group: The subjects were asked to sit in *sukha-asana* with spine in upright posture and practice awareness towards inhalation and exhalation (breath awareness).

Assessment: The subjects will be recorded for the following assessments: Blood pressure, Autonomic Variables: Respiration(R): Blood pressure (BP):Heart rate variability spectrum (HRV)**,** Cognitive function test: Rey auditory learning test, Digit span memory test , Attention questionnaire, Anxiety questionnaire.

Data extraction: The data assessment was done at baseline (pre) and at the end of the practice (post). The data was organised in Microsoft excel sheet (version 2010).

Data Analysis: Appropriate statistical tests were done to assess the mean difference across the baseline and the end of practice based on the quality of data normality and distribution. Data obtained immediately after the intervention were analyzed for normal distribution using the Shapiro Wilk test. Normally distributed data were analyzed further using independent t-test whereas deviation from normality was assessed using the Mann Whitney U test .Further Mann-Whitney U test was done to compare the difference between two independent groups when the dependent variable was continuous but not normally distributes for Digit Span Memory, RAVLT, Anxiety Questionnaire, Systolic Blood Pressure (mmHg), diastolic Blood Pressure (mmHg), Respiratory Rate (CPM). Independent samples t-test was conducted for comparison and assumption for random sampling in Attention questioner (SLCT) Pulse Rate

(bpm). Within the group Paired t-test and Wilcoxon Signed Rank test was done for statistical evidence. Repeated Measures ANOVA with Bonferroni Corrections were done for HRV variables.

Results:

The present study was conducted to look for the influence of the immediate effect of alternative nostril breathing on cognitive functions and autonomic variables. The results were compared between baseline practice (pre intervention) and end point practice (post intervention).In case group result with respect to attention (29.6 to40.9)(p= 0.001)digit span memory (51.3 to 74.3) (p= 0.001), RAVLT (10.2 to 15.5) (p= 0.001), anxiety score were decreased from pre to post (11.4 to 9.17) (p= 0.001).The results of autonomic variables : pulse rate (75.3 to 74.7), respiration rate (16.9 to 16.6), systolic blood pressure (116.6 to114.3) and diastolic blood pressure (74.8 to 74.1).In Control group the results with respect to attention score (27 to 25), RAVLT (11.43 to 11.2), anxiety score (11.5 to 11), Digit span memory (40.9 to 41.8), the autonomic variables :pulse rate (72.5 to 72.7) systolic blood pressure (115 to 115.1) and respiratory rate(17.1.to 17.2) diastolic blood pressure was decreased from (77.4 to 77.1). But the significant p value was evident only in attention questioner p= 0.003

Test of Normality (Shapiro-Wilk)

		W	p
Attention questioner (SLCT)-Pre	- Attention questioner(SLCT)-Post	0.962	0.341
Digit span Memory-Pre	- Digit span memory-Post	0.764	< .001
RAVLT -Pre	- RAVLT-Post	0.952	0.196
Anxiety questioner-Pre	- Anxiety questioner -Post	0.910	0.015
pulse- Pre	- pulse- Post	0.924	0.034
Pre-SBP	- post-SBP	0.955	0.223
pre-DBP	- Post-DBP	0.928	0.044
Respiration -Pre	- Respiration- Post	0.946	0.128

Note. Significant results suggest a deviation from normality.

Within Group assessments: Group 1 case group

Variable	t/W score	p-value	Effect Size
Attention questioner (SLCT)[a]	-14.474	<0.001	-2.643
Digit Span Memory[b]	29.00	<0.001	-0.875
RAVLT[a]	-18.916	<0.001	-3.454
Anxiety Questionnaire[b]	349.00	<0.001	0.989
Pulse Rate (bpm)[a]	0.418	0.679	0.076
Systolic Blood Pressure (mmHg)[a]	1.958	0.060	0.357
Diastolic Blood Pressure (mmHg)[b]	177.50	0.695	0.092
Respiratory Rate (cpm)[a]	0.921	0.365	0.168

a-paired samples t-test, b-Wilcoxon Signed Rank test. For the paired samples t-test, the effect size is given by Cohen's *d*; for the Wilcoxon test, the effect size is given by the matched rank biserial correlation.

Test of Normality (Shapiro-Wilk)

			W	p
Attention questioner (SLCT)-Pre	-	Attention questioner(SLCT)-Post	0.963	0.361
Digit span Memory-Pre	-	Digit span memory-Post	0.765	<.001
RAVLT -Pre	-	RAVLT-Post	0.957	0.259
Anxiety questioner-Pre	-	Anxiety questioner -Post	0.569	<.001
pulse- Pre	-	pulse- Post	0.951	0.182
Pre-SBP	-	post-SBP	0.923	0.032
pre-DBP	-	Post-DBP	0.950	0.167
Respiration -Pre	-	Respiration- Post	0.875	0.002

Note. Significant results suggest a deviation from normality.

Within Group assessments: Group 2 control group

Variable	t/W score	p-value	Effect Size
Attention questioner (SLCT)[a]	3.248	0.003	0.593
Digit Span Memory[b]	74.00	0.249	-0.295
RAVLT[a]	0.520	0.607	0.095
Anxiety Questionnaire[b]	36.00	0.013	1.00
Pulse Rate (bpm)[a]	-0.237	0.814	-0.043
Systolic Blood Pressure (mmHg)[b]	101.50	0.910	-0.033
Diastolic Blood Pressure (mmHg)[a]	0.370	0.714	0.068
Respiratory Rate (cpm)[b]	39.00	0.398	-0.257

a-paired samples t-test, b-Wilcoxon Signed Rank test. For the paired samples t-test, the effect size is given by Cohen's *d*; for the Wilcoxon test, the effect size is given by the matched rank biserial correlation.

Variables	Group 1 (n=30)		Group 2 (n=30)		Between groups t/W scores		Between Group p-value		Effect Size
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post - Post
Attention questioner (SLCT)[a]	29.60±6.32	40.90±5.62	27.03±7.69	25.00±7.51	1.412	9.282	0.163	<0.001	2.397
Digit Span Memory[b]	51.37±272.5	74.33±26.17	40.90±29.62	41.80±29.03	544.00	725.50	0.165	<0.001	0.612
RAVLT[b]	10.20±2.20	15.50±1.70	11.43±2.14	11.20±1.37	304.00	882.00	0.029	<0.001	0.960
Anxiety Questionnaire[b]	11.47±2.91	9.17±1.78	11.50±2.64	11.00±2.24	458.50	244.00	0.904	0.002	-0.458
Pulse Rate (bpm)[a]	75.30±8.64	74.73±5.57	72.57±6.16	72.73±5.24	1.376	1.433	0.174	0.157	0.370
Systolic Blood Pressure (mmHg)[b]	116.60±95.9	114.33±5.04	115.00±8.35	115.13±5.77	472.50	409.50	0.742	0.541	-0.090
Diastolic Blood Pressure (mmHg)[b]	74.87±8.85	74.13±5.46	77.47±7.04	77.13±5.16	344.00	318.00	0.114	0.045	-0.293
Respiratory Rate (cpm)[b]	16.97±1.38	16.67±1.47	17.10±1.21	17.27±1.39	425.50	342.50	0.714	0.106	-0.239

Descriptive Statistics

a -Independent samples t-test, Attention questioner (SLCT) and Pulse Rate (BPM)b- Mann-Whitney U test =Digit Span Memory, RAVLT, Anxiety Questionnaire ,Pulse Rate (bpm) ,Systolic Blood Pressure (mmHg) ,Diastolic Blood Pressure (mmHg),Respiratory Rate (cpm)For the Mann-Whitney test, effect size is given by the rank biserial correlation. For the other test(s), by Cohen's d.

Variable	Group 1			Group 2			Within subject effects		Between subject effects	
	Pre	During	Post	Pre	During	Post	F Value	p-value	F Value	p-value
Mean HR	81.33±10.91	79.70±8.49	78.83±8.80	74.87±11.23	77.37±10.62	75.87±13.66	1.116	0.331	3.237	0.077
SDNN	82.19±54.92	100.90±60.91	94.61±69.41	85.42±42.52	75.28±57.31	117.29±96.95	4.231	0.017	<0.001	0.995
RMSSD	95.21±75.61	107.95±75.81	110.07±96.93	100.95±54.88	79.95±74.66	124.16±130.26	1.614	0.204	0.028	0.868
pNN50	32.89±24.93	36.45±21.40	34.80±28.05	32.69±19.83	26.62±17.85	43.94±24.54	7.799	<0.001	0.003	0.955
LFnu	48.88±24.31	54.44±17.02	45.85±21.76	35.33±17.47	36.33±16.47	41.78±15.53	3.311	0.040	10.267	**0.002**
HFnu	49.91±23.25	43.06±17.77	51.80±22.51	64.40±16.89	63.28±16.26	59.07±15.95	2.645	0.075	14.545	**<0.001**
LF:HF Ratio	1.70±2.04	1.79±2.05	1.36±1.68	0.70±0.78	0.77±1.06	0.81±0.51	0.626	0.536	10.334	**0.002**

Repeated measures ANOVA for HRV variables

DISCUSSION

The present study was conducted to evaluate and compare the effect of 20 minutes of alternative nostril breathing on cognitive function like memory, attention, learning and autonomic variables like pulse rate ,blood pressure, respiration rate and HRV components.

In this study positive result was suggested in case group with respect to attention, digit span memory, RAVLT, by showing the increase in post intervention value compared to the pre intervention suggesting the positive impact and influence of alternative nostril breathing on learning, memory and attention. The study also gave positive impact on anxiety score. The anxiety score were decreased from pre to post suggesting that alternative nostril breathing decreases the anxiety in an individual and can directly influence positively on the cognitive aspects. The autonomic variables like pulse rate respiration rate, systolic blood pressure and diastolic blood pressure were decreased showing decrease in sympathetic activity and increase in parasympathetic activity. The significant p value (<0.05) changes was seen the attention questioner<0.001, RVLT<0.001, digit span memory<0.001, and anxiety questioner <0.001.The present study showed significant improvement in the cognitive domains and decrease in anxiety scores. This could be related to Study done by Vivek Sharma which showed specifically significant reduction in perceived stress and improvement in the following cognitive domains: attention, visuo-motor speed and memory retention capacity in both fast(kapalbhahi, bastrika) and slow pranayama(savitri,nadishodana, pranava) groups. In the same study it was suggestive that Prefrontal cortex regulates physiological functions by integrating information from ongoing cognitive processes, emotional processes and current stress level .Chronic (perceived) stress alters normal patterns of prefrontal cortex activation during cognitive tasks, resulting in enhanced autonomic arousal. Reduced stress in both pranayama groups could have enabled their improved cognitive functions. (19) Our results were consistent with those of previous studies, which found significant improvement in various cognitive domains with the practice of alternative

nostril breathing techniques. In our study anxiety level were decreased after the intervention. This was comparably to study done by *Brown* on yogic breathing in the treatment of stress, anxiety, and depression. The particular contribution of pranayama to stress reduction might be mediated by the bidirectional vagal system. Vagal afferents from peripheral receptors are connected with the nucleus tractus solitarius from which fibers ascend to the thalamus, limbic areas and anterior cortical areas. The descending projections then modulate autonomic, visceral, and stress arousal mechanisms at the different levels of the neuraxis. (20)The study result shows decrease in respiratory rate after the intervention of alternative nostril breathing and breath awareness. A decrease in breath rate has been associated with relaxation and its related with the increased vagal tone and overall reduction in arousal during and after ANB. Slow breathing reduced chemo reflex sensitivity to both hypoxia and hypercapnia, which attributes an inverse relationship with Baro-reflex sensitivity. The decline in respiratory rate in the study can be explained by the influence of a probable hypocapnoea on medullary respiratory center and persistent voluntary effort of breathing (ANB), producing inhibition of rhythmic spontaneous breathing by a phenomenon similar to over drive suppression.(21)In this present study result showed decrease in heart rate and SBP after the intervention. The heart rate is regulated by dual innervation (sympathetic and vagal) as well as humoral factors (22). Slow Breathing is known to increase vagal modulation of sinoatrial (SA) and atrioventricular nodes and enhances baroreceptor sensitivity. This may be responsible for reduction in HR and the BP indices (23).The systolic blood pressure is determined by the cardiac output,varies more within a short period than the diastolic blood pressure.(24,25) Previous study done by Telles *etal* is in accordance with our present study which concludes that eighteen minutes of alternate-nostril yoga breathing (ANYB) in 26 healthy volunteers was found to lower the systolic blood pressure by an average of 4.5 mmHg as an immediate effect.(26)

Present study shows significant increase in RMSSD, NN50, which are the components of HRV. These significant increases could be due to vagal dominance during and after ANB. The shift towards vagal dominance during and after ANB could be one of the factors responsible for the reduction in blood pressure after practicing ANB.(27) But in the study Mean RR interval, was decreased from the time domain measures of the heart rate variability (HRV), i.e., RMSSD, NN50 and the mean R-R interval have been recognized as stronger predictors of vagal modulation.(28) Yogic practice modulates the levels of stress, and decrease anxiety may increase levels of serotonin in the practitioner. Stress reduction is due to relaxation of central and or autonomic nervous system is reflected by the levels of HRV components. This study showed significant decrease in low frequency (LF), LF/HF ratio and significant increase in high frequency (HF) of HRV spectrum. The results are in accordance with the earlier study done by *Bhimani etal,* concludes that practice of pranayama reduces the Low frequency (LF) of HRV spectrum which is indicative of reduction in sympathetic drive to heart; and increase in high frequency (HF) of HRV spectrum is indicative of increase in parasympathetic output to the heart and reduction in LF/HF ratio which indicates better sympatho-vagal balance. (29)In the present study result suggestive of parasympathetic dominance, this might be due to slow breathing during pranayama practice activates the adaptation of lung receptors during tidal volume inspiration which increases the frequency and duration of inhibitory neural impulses which is known as the Hering-Breuer reflex. These inhibitory impulses affect systemic vascular resistance and heart rate. The rhythmic breathing pattern leads to synchronization within the hypothalamus and brainstem which induces the parasympathetic dominance. (30)Another probable mechanism could be due to, the acts of breath concentration during the practice relaxes and de-stress the individual. Stress free individual adapts or cope up better to the emotional, physical and mental stress. This stress free state of mind evokes relaxed responses. In this relaxed state, this again indicates the dominance of parasympathetic activity. (31)The results of the present study indicate the short-term practice of alternative nostril breathing or Nadi-Shodana pranayama induces parasympathetic dominance and improve cognitive function.

Strengths of the study:

The study had a Standard assessment equipment is used to assess HRV hence a precise, reliable data was obtained. No acute adverse effects documented. High compliance. It was a Randomized controlled trail.

Limitations of the study:

Room temperature was not maintained during the assessment. Diurnal variations might have influenced the results. Sample size is small. Long-term effects of *Nadi-Shodana* pranayama on HRV and Respiratory variables were not assessed.

Directions for the future study: Intervention period can be increased. Study can be conducted with a large sample size

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