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ORIGINAL RESEARCH ARTICLE

Effect of *Nadishodhana Pranayama* on Cognitive Function among Healthy Individuals

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ABSTRACT

Background and Objectives: The *Nadishodhana pranayama*, alternate nostril breathing, activates and harmonizes *ida* and *pingala nadis*. This study aimed to evaluate the effect of commonly practiced *Nadishodhana pranayama* on cognitive functions in healthy individuals.

Materials and Methods: A randomized control trial of 60 subjects of age group fulfilling inclusion and exclusion criteria was recruited and randomly assigned to Group 1 study group (n = 30) and Group 2 control group (n = 30). *NSP* training was given for 15 min per session, 6 days per week for the duration of 8 weeks. Pre and post-parameters were recorded. Assessments were done using cognitive parameters letter cancellation test, trail-making tests A and B, forward and backward digit spans.

Results: The study assessed the effect of *Nadishodhana pranayama* on executive functions. The data were tested for normality using the Shapiro–Wilk test. Within-group comparisons and between-group comparisons were made using paired t-test and independent sample test consecutively. Within-group comparisons for study group showed a significant improvement in SLCT (P = 0.0028) and digit span forward (P < 0.0005). Interestingly, there was a significant reduction in digit span backward (P = 0.005) in the control group. Between-group comparisons showed a significant improvement in the digit span forward test following the intervention (P = 0.003). The results suggest that *Nadishodhana pranayama* is beneficial for cognitive functions.

Interpretation and Conclusion: *Nadishodhana pranayama* practice is beneficial for improving cognitive functions. Hence, it can be prescribed as effective modality to improve attention and manipulation in auditory working memory.

1. INTRODUCTION

Yoga is an ancient science, which originated in India.[1] About 4,000 years ago, the practice of yoga became increasingly common in Western countries.[2] It includes diverse practices such as physical postures (*asanas*), regulated breathing (*pranayama*), meditation, and lectures on philosophical aspects of yoga.[3]

Pranayama has been assigned a very important role in yogic system of exercises and is said to be much more important than *yoga asanas* for keeping sound health.[4] The word *pranayama is* comprised of two roots: "Prana" plus "*ayama*." Prana means "vital energy" or "life force." The word *yama* means "control;" *ayama* is defined as "extension" or "expansion." Thus, the word *pranayama* means "extension or expansion of the dimension of Prana."[5] Hatha yoga, as described in the early Yoga Upanishads, was made up of the *shatkarmas* and is a very precise and systematic science.

Nadi is like a stalk of Lotus those are directed inferiorly and lies in the vicinity of vertebral column.[6] *Nadi* is a structure through which something flows inside it.[7] It is a medium for flow of energy (vital power). The practice of *pranayama* sets right the flow of energy which is impaired by our defective diet and life style.[8] *Sushumna* is hidden, along with *ida* and *pingala;* these three *nadis* meet at *triveni* point which lies at site of Ajna chakra behind the center of two eyebrows.[9] Normally both *ida* and *pingala* act alternately. *Ida* and *pingala* are connected to *mooladhara* chakra and upward surrounding *sushumna* in all directions to join with *ajna chakra*. Then, these *nadis* get separated to establish an association with the left and right nostrils. *Sushumna*

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nadi originates from *mooladhara* and is continuous up to *brahma-randhra* which is situated at root (base) of skull.

Pranayama constitutes voluntary breathing exercise. *Puraka* (inhalation), *kumbhaka* (retention), and *rechaka* (exhalation) are the three essential phases of *pranayama*.[4,10] The *nadishodhana pranayama* or alternate nostril breathing, activates and harmonizes ida and pingala nadis. *Shodhana* means "to purify" in English; this practice is called "*nadi* purification" pranayama.[11] Alternate-nostril breathing (ANB) is a type of *pranayama* that involves left nostril inhalation followed by right nostril exhalation and then right nostril inhalation followed by left nostril exhalation. Several investigations have been conducted to determine the long-term effects of this technique on the cardiovascular and autonomic nervous systems in healthy and clinical populations and many of these studies have suggested that ANB leads to a shift in sympathovagal balance toward parasympathetic dominance.[12]

Cognition is derived from the Latin word "cognitio" which in turn comes from "cognocere" meaning "to come to know".[13] Cognition is a general term used to denote thinking and many other aspects of our higher mental processes.[14] Cognitive processes are thus the mental processes involved in knowing about the world; as such, they are important in perception, attention, thinking, problem solving, decision-making, and memory in short, all aspects of the human mind.[15,16] Perception refers to the way the world looks, sounds, feels, tastes, or smells. In other words, perception can be defined as whatever is experienced by a person.[17] Attention is the term given to the perceptual processes that select certain inputs for inclusion in our conscious experience, or awareness, at any given time.[18] Thinking, an activity that involves the manipulation of mental representations of various features of the external world. Thinking includes reasoning – mental activity through which we transform available information to reach conclusion. Problem solving typically involves processing information in various ways to move toward the goals. Decision making is the process of choosing between two or more alternatives on the basis of information about them.[14] Memory-the encoding, storage, and retrieval of what was learned earlier. Encoding is the process of receiving sensory input and transforming it into form, or code, which can be stored; storage is a process of actually putting coded information into memory; and retrieval is the process of gaining access to stored, coded information when it is needed.[15] There has been important interest in cognitive enhancement in recent years, which include numerous investigations of the potential cognitive benefits of computerized cognitive training.[19,20] On meta-analysis of the efficacy of computer-based cognitive training programs suggests minimal effects on cognition and behavior.[21,22] Therefore, researchers have begun to discover cognitive enhancement through mind–body practices (e.g., mindfulness training, yoga, meditation). Preliminary studies recommend that yoga practice could lead to improved cognitive performance, among other potential benefits in healthy adults.[23-25] A meta-analysis of both short- and long-term effects indicates that yoga practice is associated with improvement in cognitive functioning generally in both long-term and short-term studies, medium effect sizes reported in short-term studies related to measures of attention, processing speed, and executive functioning. However, as the limited number of studies and the heterogeneous use of cognitive tests indicate, yoga practice should be considered preliminary evidence for cognitive improvement.[24]

There are few studies of *pranayama* which shown beneficial effect in improving cognitive function among children, but to the best of our knowledge, no studies are reported on effect of *nadishodhana* pranayama on cognitive function among healthy individuals. Hence, the present study aimed to evaluate the role of *nadishodhana pranayama* on cognitive function among healthy individuals and to draw a conclusion for its therapeutic application in clinical practice.

2. MATERIALS AND METHODS

2.1. Study Design

Randomized controlled design.

There was screening for 100 eligible subjects, after meeting inclusion and exclusion criteria, 60 healthy individuals will be selected and randomly divided into 2 groups (study group n = 30 and control group n = 30). For both the group, pre-assessment will be recorded. Then, study group will practice *Nadishodhana pranayama* 15 min per session, 6 days per week for the duration of 8 weeks, control group will be observed without any pranayama intervention. Post-assessment will be recorded immediately after 8 weeks of intervention for study and control group. Signed informed consent prepared in English and local language and will be obtained from every participant after an appraisal about the study protocol. Ethical clearance is obtained from the institutional ethical committee.

2.2. Study Area

Alva's College of Naturopathy and Yogic Sciences, Mijar.

Alva's Homeopathy Medical College, Mijar.

2.3. Diagnosis Criteria

Since the study involves normal healthy subjects, no diagnostic criteria will be applicable to the present study.

2.4. Inclusion Criteria

- Both genders (male and female).
- Age group between 18 and 26 years will be enrolled for the study.

2.5. Exclusion Criteria

- Students taking medication, psychiatric drugs, alcohol, or tobacco in any form
- Spinal deformity
- Those who are regularly practice Nadishodhana pranayama from the past 6 months.

2.6. Study Size

n = 60.

2.7. Study Period

8 week.

2.8. Study Sample Size

Potential subjects will be screened out of which 60 healthy eligible subjects will be recruited for the study.

2.9. Grouping

2 groups-Group A and B.

- Group A – *Nadishodhana Pranayama* Group, n = 30
- Group B – Control Group, n = 30.

Control group will be observed without any yoga and *pranayama* intervention

2.10. Ethical Considerations

Subjects who fulfilled the inclusion criteria were explained about the study protocol and all the details of the intervention. They were given the opportunity to ask any question and if they agreed to participate in the study only, they were asked to sign the informed consent form. Study was approved by the institutional ethical committee and informed consent was obtained from all the subjects.

2.11. Study Design

2.11.1. Randomized controlled design

A total of 60 subjects were selected after considering inclusion and exclusion criteria and randomly divided into two groups (study group 1 $n = 30$ and control group 2 $n = 30$) using a random number table. Hence, there were an equal number of subjects (30 each) in the study group and control group. For both, the group pre-assessment was taken before the study. Then, the study group practiced *Nadishodhana pranayama* 15 min per session, 6 days per week for the duration of 8 weeks, the control group was observed without any pranayama intervention. Post-assessment was taken after 8 weeks of intervention for study and control group.

2.12. Assessments

Data extraction was done at baseline and post-intervention after (8 weeks) from the subjects for which assessments under the following tools were done.

The subjects were recorded for the following assessments as per the standard operating procedures before and after the intervention of Nadishodhana pranayama. Assessments were done for six-letter cancellation test (SLCT), trial-making tests A and B, and forward and backward digit span as mentioned below.

2.12.1. SLCT

SLCT is useful for assessing functions such as selective attention, focused attention, visual scanning, and the activation and inhibition of rapid responses.[26,27]

2.12.2. Trail-making test (TMT) parts A and B

The TMT is a measure of attention, speed, and mental flexibility. Both parts of the TMT consist of 25 circles distributed over a sheet of paper.

2.12.3. Scoring

Table 1 and Figure 1.

2.12.4. Digit span test

The Digit Span test is one of the most commonly used measures of immediate verbal recall, attentional capacity, and working memory in neuropsychological research and clinical evaluations. This test comprises two modalities, digits forward and digits backward.[32]

2.13. Intervention

2.13.1. Procedure of intervention

The subject selected for the study was randomly assigned into study group and control group.

2.13.2. Intervention to study group

Table 2 and Figure 2.

2.13.3. Control intervention

No intervention was given to control group, and they were asked to continue with their normal routine.

2.14. Data Extraction

Assessments were done on the 1st day and end of 8 weeks. Selective attention, focused attention, visual scanning, and the activation and inhibition of rapid responses were assessed by SLCT. Assessment of attention, speed, and mental flexibility was done by TMT Parts A and B. Digit Span Test (forward and backward) did the assessment of immediate verbal recall, attentional capacity, and working memory.

2.15. Data Analysis

Statistical analysis of the data was done using IBM SPSS Statistics (Version 23.0) Software package. Data were checked for normal distribution and baseline analysis was performed to assess the changes between respective groups. $P < 0.001$ was accepted as indicating significant differences between pre and post-intervention data.

3. RESULTS

The study was conducted to assess the effect of *nadishodhana* pranayama on executive functions including SLCTs, TMT, and digit span tests. Subjects were randomly recruited into two groups either the experimental group or the control group. Assessments were performed at baseline and immediately after the practice of 15 min of *nadishodhana* pranayama for the control group and the control group performed simple sitting. The data were tested for normality using the Shapiro–Wilk test. Within-group comparisons were made using paired *t*-test and between-group comparisons were made using independent samples *t*-tests. Within-group comparisons for study group showed a significant improvement in SLCT ($P = 0.0028$) and digit span forward ($P < 0.0005$). Interestingly, there was a significant reduction in digit span backward ($P = 0.005$) in the control group. Between-group comparisons showed a significant improvement in the digit span forward test following the intervention ($P = 0.003$) (Table 3 and Figure 3).

4. DISCUSSION

In support of our results, a previous study on differential effects of uninostril and alternate nostril *pranayama* on cardiovascular parameters and reaction time shows the sympathomimetic effects of right nostril initiated *pranayamas* with sympatholytic/parasympathomimetic effect following left nostril initiated *pranayamas.* The main effect of UNB and ANB techniques is determined by the nostril used for inspiration rather than that used for expiration. They concluded that right and left yogic UNB and ANB techniques have differential physiological effects that are in tune with the traditional *swara* yoga concept that air flow through the right nostril (Surya *nadi* and *pingala swara*) is activatory in nature, whereas the flow through the left nostril (Chandra *nadi* and ida swara) is relaxatory.[33] A study on unilateral nostril (left – nostril and right – nostril) breathing on spatial and verbal memory shows increase in spatial memory and verbal performance. By practicing unilateral forced nostril breathing, there is greater cognitive ability in one hemisphere, so by altering the breathing pattern cognitive performance ratios can be influenced.[34] Immediate effects of alternate nostril breathing on HRV in non-practitioners of yogic breathing are very different from the long-term influence of yogic breathing on HRV which show a predominant parasympathetic influence on the heart.[33] Surya *anuloma viloma* a right nostril yoga breathing leads to improvement in digit span forward and digit span backward and alternate nostril breathing increases the digit span backward task score. Another study assessed the cognitive abilities following *kapalbhati* on the performance of six-letter cancellation and digit letter substitution tasks showing increase in the number of errors following 1 and 5 minutes of practice of KB, in a six-letter cancellation

and digit letter substitution tasks. Net scores were increased after *kapalbhati* by 32.5% and 16.4%, respectively.[33,34] A study comparing the effects of slow and fast pranayama on cognitive function shows significantly improved in executive functions, perceived stress scale, and reaction time in both fast and slow pranayama groups, except reverse digit span, which showed an improvement only in fast pranayama group.[35] Yoga seems to have positive effects on brainwave activity in terms of stimulating the activation of alpha, beta, and theta brainwaves, which have been associated with improvements in cognition, memory, mood, and anxiety. Yoga training has been correlated with decreased amygdala activation and decreased negative emotion in response to emotional distracter images. Alternate nostril breathing was reported to activate the contralateral brain hemisphere, providing neurocognitive benefits. Increased inter-hemispheric coherence and symmetry with yoga training have been reported in multiple studies. Yoga also seems to have a constructive effect on the anatomy of the brain.[36] Our results were consistent with those of previous studies, which found significant improvement in various cognitive domains with the practice of different yoga breathing techniques. Thus, a significant improvement was seen in various cognitive areas: attention, memory retention capacity, and visuomotor speed were observed after pranayama intervention. *Nadishodhana* pranayama practice conveys the benefit on cognitive function and neural activity which means improvement in the following cognitive domains: Selective attention, focused attention, visual scanning, and the activation and inhibition of rapid responses immediate verbal recall, attentional capacity, and working memory in *nadishodhana* pranayama groups. The improvement in attention and working memory in *nadishodhana* pranayama groups could have enabled their improved cognitive functions. Hence, *nadishodhana* pranayama can be prescribed as an effective modality to improve, attention, and memory.

5. CONCLUSION

Nadishodhana pranayama practice is beneficial for improving cognitive functions; hence, *nadishodhana* pranayama can be prescribed as an effective modality to improve, attention, and manipulation in auditory working memory, i.e., short-term memory further research with a larger sample size and duration is warranted to reveal accurate changes in this field.

6. ACKNOWLEDGMENTS

None.

7. AUTHORS' CONTRIBUTIONS

All the authors contributed equally in the design and execution of the article.

8. FUNDING

Nil.

9. ETHICAL APPROVALS

This study is cleared by the Institutional Ethical Committee of Alva's College of Naturopathy and Yoga Sciences Ref. no. BNYS/PG/2016-2017 dated 04/05/2017.

10. CONFLICTS OF INTEREST

Nil.

11. DATA AVAILABILITY

This is an original manuscript and all data are available for only research purposes from principal investigators.

12. PUBLISHERS NOTE

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Table 1: Results for both TMT A and B are reported as the number of seconds required to complete the task; therefore, higher scores reveal greater impairment[28-31]

	Average	Deficient	Rule of Thumb
Trail A	29 s	>78 s	Most in 90 s
Trail B	75 s	>273 s	Most in 3 min

Table 2: Intervention procedure for the study group

Nadisuddhi pranayama	Normal breathing	*Nadisuddhi pranayama*	Normal breathing	*Nadisuddhi pranayama*	Normal breathing	*Nadisuddhi pranayama*	Normal breathing	*Nadisuddhi pranayama*	Normal breathing
2 min	1 min	2 min	1 min	2 min	1 min	2 min	1 min	2 min	1 min

Table 3: Comparison of pre-test and post-test values of cognitive test parameters in both groups (Mean±SD)

Variable	Group 1 study group (*n*=30)			Group 2 Control group (*n*=30)			Between group *P*-value
	Pre (Mean SD)	Post (Mean SD)	*P*-value	Pre (Mean SD)	Post (Mean SD)	*P*-value	
LCTNA	36.53333±9.895082	31.66667±8.856454	0.0028	34.83333±7.168337	35.56667±8.973844	0.64	0.096
TMA	30.62333±12.17331	28.15233±5.35594	0.341873	24.34767±8.984574	26.01667±9.384436	0.15	0.28
TMB	55.38667±7.275549	52.95267±8.702997	0.2	49.97767±11.55289	50.461±10.00074	0.74	0.31
DSF	10.7±2.380235	12.96667±2.07586	<0.0005	11.9±2.006025	11.4±1.886431	0.15	0.003
DSB	6.766667±2.329471	7.6±2.724094	0.111	9.433333±2.238893	8.166667±2.214114	0.005	0.38

LCTT: Letter cancelation test total attempted, LCTNA: Letter cancelation test net attempted, TMA: Trail-making test A, TMB: Trail-making test B, DSF: Digit span forward, DSB: Digit span backward

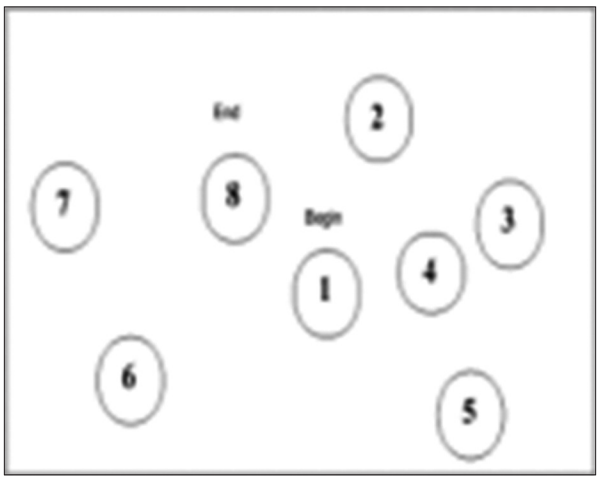

Figure 1: Trail making test Part A and trail making test Part A-sample[28-31]

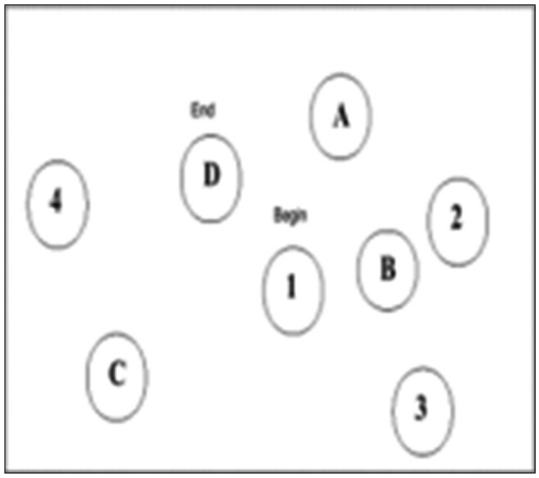

Figure 2: Trail-making test Part B and trail-making test Part B-sample trail making test Part B and trail making test Part B-sample[28-31]

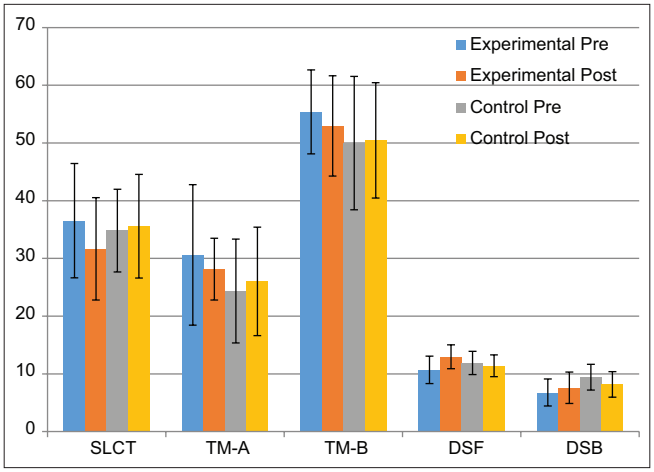

Figure 3: Graphical representation of pre and post-study results