Evaluation of Attention and Verbal Memory in Yoga Practicing Pre-Adolescents: A Cross-Sectional Study

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ABSTRACT

Background and objectives: Yoga is a holistic mind–body practice used for physical and mental health, which is most commonly looked upon by educators as a wellness program for students. This study aims to analyze whether pre-adolescent school students who practiced yoga performed better in attention and memory tasks in comparison with controls that did not practice yoga.

Design and interventions: This is a single-center cross-sectional study involving healthy students between grades 3 and 9 (8–14 years of age) from the same school. Forty students who practiced yoga (yogic breathing and postures) for 30 minutes, 5 days a week in the past 12 months (Y group) were assessed against a control group of 40 students in the same age group (NY group) who were not involved in any yogic practices for differences in scores of trail making tests (TMT), Stroop color task, and digit memory tests. Data were analyzed using independent samples *t*-test with a confidence interval of 95% and $P<0.05$ considered statistically significant.

Main outcome measure: To establish the difference in scores of visual attention, selective attention, and verbal memory/auditory attention between the groups.

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ABSTRACT (CONTINUED)

Results: The mean scores for TMT-A (joining numbers in numerical order) were 42.7±21.66 in the Y group compared with 50.8±22.0 for the NY group (P=0.02). Mean scores of TMT-B (joining numbers in intermittent order) were 91.4±34.9 in the Y group compared with 125.7±48.3 in the NY group. The mean scores of digit span forwards in Y and NY groups were 9.82±1.72 and 7.62±1.67, respectively. Digit span backward scores in Y and NY groups were 8.75±22.07 and 5.8±4.82, respectively. The mean scores of Stroop color test in Y and NY groups were 2.02±1.94 and 4.21±1.87, respectively, which were statistically significant (P<0.0001).

Conclusion: Pre-adolescent school students who practiced yoga in the past 12 months showed better performance in visual attention, selective attention, and verbal memory/auditory attention compared with the pre-adolescent controls. Randomized controlled trials are needed to assess the generalizability of these study findings.

Keywords: Attention span; Pre-adolescents; Yoga; Memory; Yogic breathing; Yogic postures

INTRODUCTION

Pre-adolescence is a stage of human development following early childhood, prior to adolescence.[1] Pre-adolescence and adolescence are very critical stages in the physical and intellectual development of an individual. Most of the physiological, psychological, and social changes within a person take place during this period of life. Adolescence can be looked upon as a time of more struggle and turmoil than experienced in childhood. Adolescents have long been regarded as a group of people who are searching for themselves to find some form of identity and meaning in their lives. Freud called this stage the *latency* period to indicate that sexual feelings and interest went underground; the feelings that create that first "eternal triangle" with the parents fade, and free energy for other interests and activities increase.[2]

Cognitive and educational development of pre-adolescence is based on "attention,"[3] which is defined as the behavioral and cognitive process of selectively concentrating on a discrete aspect of information, whether deemed subjective or objective, while ignoring other perceivable information.[4] An attention system enables the selection of relevant information, focuses on stimuli of individual interest, and sustains the processing of information over a longer period of time.[5]

Yoga is one of the ancient holistic mind–body practices that involve physical and mental exercises and is defined as "The rising and expansion of consciousness." Yoga is a form of physical activity consisting of various physical postures *(asana)*, breathing techniques *(pranayama)* and meditation techniques *(dhyana)*.[4] It has been used since early in history as a remedy for various diseases and also as a supportive non-pharmacological intervention in many ailments.[6]

Previous studies evaluating the efficacy of yoga in achieving specific outcomes in school-going children have assessed outcomes on anxiety, depression, stress, confidence, and quality of life. A study by Verma *et al.* evaluated cognitive performance in middle and high school students who practiced *hatha* yoga for 12 weeks, against a control group, and reported significant improvement in measures of mental ability and memory in the experimental group.[7] Tells *et al.* assessed self-esteem, physical fitness, and attention in elementary and middle school students (8–13 years of age) who did *hatha* yoga for 3 months against a control group using parameters such as the Stroop color-word task for children, Battle's self-esteem inventory, and the teachers' rating of the children's obedience, academic performance, attention, punctuality, and behavior with friends and teachers.[8] None of these studies specifically assessed visual attention and selective attention along with auditory attention and verbal memory, which together form an integral part of selective and divided attention, in their studies.[9] Hence this study aims to assess visual attention, selective attention, and verbal memory/auditory attention among yoga-practicing pre-adolescents compared with a control group who did not practice yoga.

OBJECTIVES

The primary objective of the study is to determine whether participants in the yoga group perform better than the non-yoga group in attention and verbal memory tasks.

METHODS

RESEARCH DESIGN

This is a cross-sectional single-center study. The study involved assessment and comparison of selective attention, visual attention, and verbal memory/auditory attention scores between trial and control groups described in the section on sampling technique. Strengthening The Reporting of Observational study in Epidemiology (STROBE) guidelines were used to design and report this study.

STUDY SETTING AND PARTICIPANT CHARACTERISTICS

Healthy pre-adolescent school students in the age group of 8–14 years (studying in grades 3–9)

irrespective of gender, race, and religion from a randomly selected school in Mysore, India, took part in the study. Students of both groups belonged to an urban location and their socio-economic status was categorized as lower middle class[10] with an average annual parental income of Indian Rupees 3,40,000 (USD $5095). A school was randomly selected by a computer-generated random name picker web tool from a list of schools in urban Mysore.

The participants were recruited between October and December 2014 after obtaining ethical clearance from the Independent Ethics Committee of the Ayurveda Interdisciplinary Research Minds Association (AIRMA®).

Participants who had no established cognition/learning disabilities and had no physical condition affecting their ability to participate in the study were considered eligible subjects for the study.

SAMPLING TECHNIQUES, SCREENING PROCESS AND DATA COLLECTION

Pre-adolescents were screened after taking informed consent from their caregivers and assent from participants. Those who did not agree to consent were excluded from the screening process.

A simple random sampling technique was used to recruit participants for trial and control groups to avoid selection bias.

Participants were asked whether they underwent any yogic training or other forms of physical/brain training programs in the past 12 months. A total of 150 students reported that they did not undergo any such training programs during the past 12 months, who were considered as eligible subjects for the control group. A total of 120 students reported training in yoga (specific set of yogic postures and breathing techniques detailed in Table 1) who practiced most of the components described in Table 1,

Table 1: Yogic poses *(asanas)* and yogic breathing patterns *(pranayamas)* practiced by participants.

Yoga practice	Rounds/cycles	Time
1. Initiation		
OM Chanting	5 times	3 min
2. Postures *(Asanas)*		
Sitting		
Padmasana (Lotus pose)	1 min each	3 min
Vajrasana (Diamond pose)		
Shashankasana (Rabbit pose)		
Standing		
Taadasana (Palm tree pose)	1 min each	3 min
Konasana (Angle pose)		
Vrikshaasana (Tree pose)		
Prone		
Bhujangasana (Cobra pose)	1 min each	2 min
Dhanurasana (Bow pose)		
Supine		
Pavana muktasana (Wind relieving pose)	1 min each	2 min
Utthana paadasana (Raised leg pose)		
3. Yogic breathing techniques *(Pranayama)*		
Nadi shuddhi breathing		
Bhastrika breathing	5 rounds each/	6 min
Ujjayi breathing	2 min/technique	
4. Relaxation		
Shavasana	once	5 min
Total (including 5 min time gap between changing poses and techniques)		~30 min

30 minutes, 5 days a week for the past 12 months (between October 2013 and September 2014) (Figure 1). Two different researchers did screening and assessment to avoid bias.

The regularity of the program was cross-checked with the teacher from the attendance logs to ensure that the participants practiced the program for at least 5 days a week, 30 minutes each time.

Trial group subject selection: each of 120 eligible students was assigned numbers from 1 to 120. From a box containing folded numbered chits (1–120), 40 chits were randomly picked and the person with the corresponding number was considered for the study.

Control group subject selection: similarly, each of 150 eligible students was assigned numbers from 1 to 150. From a box containing folded numbered chits (1–150), 40 chits were randomly picked and the person with the corresponding number was considered for the study.

PRIMARY OUTCOMES

The primary outcome of the study was to ascertain whether there was a difference in scores of visual attention, verbal memory/auditory attention, and selective attention between trial and control groups through a trail making test,[11] digit memory test,[12] and Stroop color test,[13] respectively.

ASSESSMENT METHODS/PSYCHOLOGICAL MEASURES ASSESSED

Both groups in the study received the following tests for assessment.

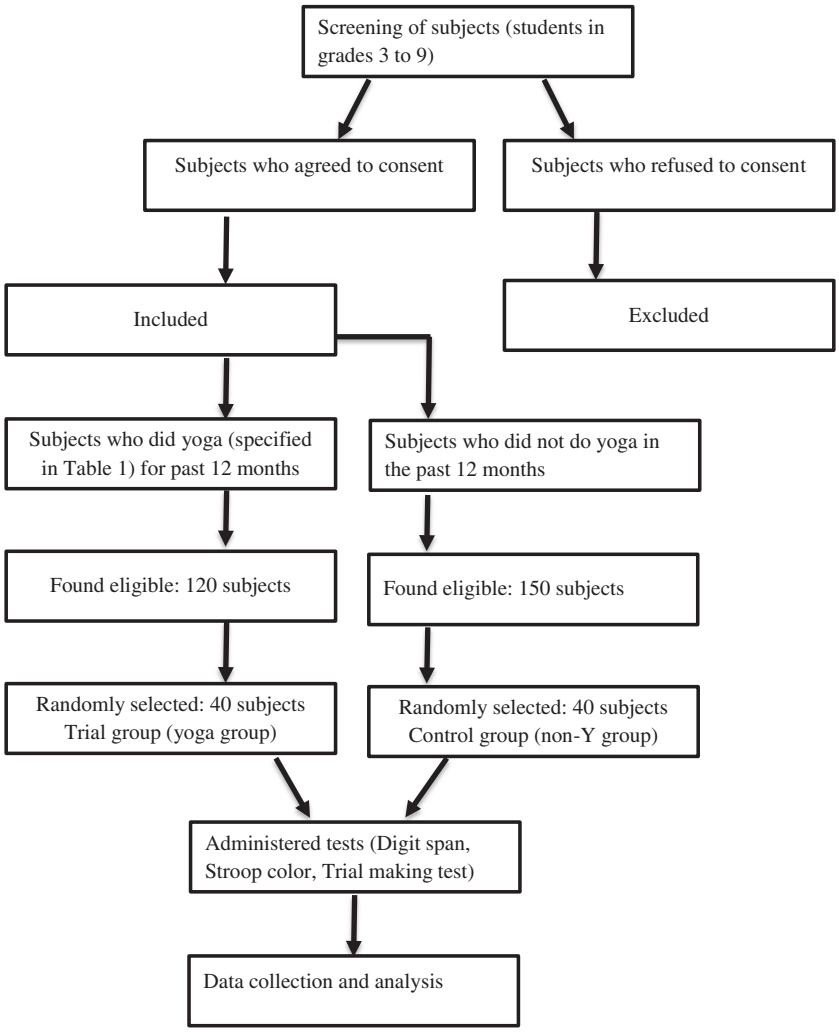

Figure 1: Procedure of participant recruitment and data collection.

1. Digit Memory Test/Digit Span Test

The digit span test was designed by Martin Turner and Jacky Ridsdale and revised in 2004.[12] It was administered to both the groups and percentiles were calculated as a norm. The digit memory test has two components as follows.

Digit Forwards

Directions: The student is instructed as follows: "Listen carefully as I say some numbers. When I finish, you say them."

Delivery: Digits are given at the rate of one per second. Both the trials of each item are administered one after the other as illustrated in Table 2. The digits are recited in an even monotone with an addition of a digit each time in an increasing order, without any variation in pitch of voice throughout the test. The test is continued till the subject fails to repeat after the assessor on both trial pairs.

Scoring: The individual's score is the total number of items correctly repeated forwards.

Digit Backwards

Directions: The student is instructed as follows: "Repeat these numbers after me but this time I want you to say them backwards."

Two practice trials of two digits are given initially. If the child gets them wrong, then they are corrected. If the student repeats the digit forwards, they are reminded that the digits are to be reversed.

Delivery and scoring is similar to digit forwards.

Final Scoring

Total number managed (ticks) backwards and forwards are added together. This can also be expressed as a percentile equivalent. This test was administered for assessment of auditory attention and verbal memory.[14]

Table 2: Digit memory test: digit forwards.

Item	First trial	✓ or X	Second trial	✓ or X
A	43	✓	16	✓
B	792	✓	847	✓
C	5941	X	7253	✓
D	93872	X	75396	X

In this example, the total score is 5.

2. Trail Making Test

The trail making test (parts A and B) was administered to both the groups and the average time taken to complete the task was noted for analysis. The trail making test assesses visuospatial component (part A) and primary working memory and task switching (part B).[11]

Trail Making Test A

The subject was instructed to join numbers on the paper from 1 to 25 in numerical order. Time taken to complete the task was recorded.

Trail Making Test B

The subject was instructed to join numbers and letters in an intermittent order.

Example: from number 1 to letter A and from A to 2 and from 2 to B, up to letter L. Time taken to complete the task was recorded.

3. Stroop Color Test

Stimuli in Stroop paradigms can be divided into three groups: neutral, congruent, and incongruent. In this study, an incongruent stimulus was used in which the ink color and word differ. The Stroop color test consisted of a page with 12 words printed in colors. The color and the word do not match; for example, the word "red" is written in green color). The respondent names the ink color of each word instead of reading the words, as quickly as possible. The test yields scores based on the number of items completed correctly.

All children were given a pre-test trial to ensure they understood the instructions. It was made sure that the participants can name all six colors (red, orange, yellow, green, purple, and brown) without difficulty.[13]

MEASURES TO AVOID BIAS

Participants were selected from the same school to avoid confounding factors like variation in the

Table 3: Mean age and distribution of study subjects.

Group	Male Mean±SD	Female Mean±SD	Mean age Mean±SD
Yoga group	11.42±1.92	10.66±1.46	11.02±1.71
Non-yoga group	12±1.96	10.79±1.84	11.27±1.96

curriculum content, teaching methods, and socio-economic variability.

All the participants recruited for the trial group attended the same yoga program with the same set of postures *(asanas)* and yogic breathing techniques *(pranayama)* to avoid variation in the yogic techniques and its possible influence on results.

The baseline characters with respect to the range of age, gender, race, and socio-economic status, which can act as potential confounding factors, were matched to the best possible extent to avoid bias.

SAMPLE SIZE, POWER, AND PRECISION

The sample size was calculated with power analysis from G-power test software based on the previous study by Drollette *et al.*[15] Type I error of 0.05 and power of 80% was considered with an expected difference in the experimental and control mean of 1.8.[16] The sample size (*N*) considered for the present study is 80 (40 each in yoga [Y] and non-yoga [NY] group).

STATISTICS AND DATA ANALYSIS

The results of the study were analyzed using descriptive statistics and checked for normality. An independent samples *t*-test was employed to compare the means of both the groups. Confidence interval was set at 95% and statistical significance at 0.05. All analyses were conducted using the statistical software SPSS v12. The *t*-value at 0.05 was 1.9904.

RESULTS

PARTICIPANT FLOW AND RECRUITMENT

All the recruited participants completed all the three tests related to attention and memory and there were no dropouts.

GENERAL DISTRIBUTION OF POPULATION/ BASELINE DATA

The average age of the participants was 11.025±1.71 years in the Y group and 11.275±1.96 years in the NY group (Table 3). The Y group included 47.5% male and 52.5% female participants. In the NY group, 40% male and 60% female participants took part in the study.

DIGIT SPAN TEST

The revised version (2004) of the digit memory test[12] was used in this study to test the selective auditory attention of pre-adolescents in both groups.

Digit forwards: The mean score in the Y group was 9.82±1.72 with a minimum score of 6 and a maximum score of 14 whereas the mean score in the NY group was 7.62±1.67 with a minimum score of 4 and maximum of 12. The difference between the groups was statistically significant with *P*<0.00001 (Table 4).

Digit backwards: The mean score in the Y group was 8.75±2.07 with a minimum score of 5 and a maximum score of 13 whereas the mean score in

Table 4: Unpaired t-test digit span scores between the groups.

	Yoga group			Non-yoga group			*t*-value	*P*-value
	Mean±SD	Min	Max	Mean±SD	Min	Max		
Digit forward	9.82±1.72	6	14	7.62±1.67	4	12	5.79	<0.00001
Digit backward	8.75±2.07	5	13	5.8±1.82	3	11	6.75	<0.00001

Table 5: Mean scores of Trail Making Test (TMT).

Tests	Yoga group Mean±SD	Non-yoga group Mean±SD
TMT-A	42.75±21.66	52.85±22.03
TMT-B	91.4±34.93	125.75±48.38

TMT-A, joining numbers in numerical order; TMT-B, joining numbers and letters in intermittent order.

the NY group was 5.8±1.82 with minimum score of 3 and maximum score of 11. The difference between the two groups was statistically significant with $P<0.00001$ (Table 4).

TRAIL MAKING TEST

A trail making test was administered for the assessment of visual attention by administration of part A and part B of the tests. The average time taken by the Y group in part A was 42.75 seconds and for the NY group it was 52.85 seconds. Y group took 91.4 seconds and NY group took 125.75 seconds in part B (Tables 5 and 6). The two-tailed *P*-value for TMT-A and TMT-B was 0.02 and <0.0001, respectively, which by conventional criteria is considered statistically significant difference between the Y and NY groups.

STROOP COLOR EFFECT

The mean error rate in the Y group was 2.025±1.96, which was lower than that of the NY group, 4.175±1.87 (Table 7). This result indicates that the focused attention of the yoga practicing group (Y) was better than that of the non-yoga group (NY) with a two-tailed *P*-value less than 0.0001.

Table 7: Comparison of mean scores of Stroop color.

Stroop Color	Yoga group Mean±SD	Non-yoga group Mean±SD	*t*-value df-79	*P*-value
	2.02±1.94	4.21±1.87	5.23	<0.0001

DISCUSSION

In the present study, pre-adolescent school students who practiced specific yogic techniques (postures and yogic breathing) in the previous 12 months showed statistically significant difference in cognitive abilities in terms of auditory attention/verbal memory, visual attention and selective attention when compared with the pre-adolescent school students from the same school who were not involved in any yogic practices in the past 12 months.

By definition, yoga not only involves various physical exercises, but also regulated breathing and meditation among other techniques.[17] It was reported by Subramanya *et al.*[18] that yoga-based relaxation techniques were effective in improving memory scores and reducing anxiety levels, which was ascribed to the meditative state of mind, awareness of body sensations, and relaxation which every yogi (one who is involved in yogic postures) assumes during yoga practice.[19]

Pre-adolescent and adolescent age-groups are two important stages at which considerable structural brain development takes place, evidenced by histological and magnetic resonance imaging studies.[17] Structural development of cortical regions during adolescence influences cognitive

Table 6: Levels of significance TMT-A and TMT-B comparison.

Tests	Yoga group Mean±SD	Non-yoga group Mean±SD	*t*-value df-79	*P*-value
TMT-A	42.7500±21.66	50.85±22.03	2.2688	=0.0260
TMT-B	91.4±34.93	125.75±48.38	9.87	<0.0001

TMT-A, joining numbers in numerical order; TMT-B, joining numbers and letters in intermittent order.

functioning with a steady increase in information-processing speed along with prospective and working memories[20–22] throughout adolescence. Given that the brain is undergoing remodeling, the adolescent period may be an especially sensitive period for environmental factors to impart their effects on brain and behavior.[23] Hence there is considerable scope for techniques like yoga as attention and memory enhancement tools for improvement of cognitive abilities in pre-adolescent and adolescent children.

Yoga ensures aerobic fitness of the brain as it involves physical exercises, regulated breathing patterns, and meditative states. Aerobic fitness of adolescents relates to spatial learning and better memory performance as it modifies the underlying neural circuitry of learning and memory processing.[24]

Visual search tasks were used in the study to assess the ability of dividing attention and shifting it between locations or objects. The ability to shift attention voluntarily and perform better in conjugation search is better in pre-adolescent children than adults as demonstrated by Trick and Enns[25] in a developmental study. Two age-related changes were found in the developmental trajectories, i.e., (1) young children were less able than either young adults or seniors to search for targets defined by conjugation of features and (2) both children and seniors were more able than young adults to move attention voluntarily from item to item. The two developmental trajectories indicate differences in feature integrations and endogenous shifts of visual attention.

In a recent study, in 2011, on developmental trajectories of selective and focused attention in children between 8 and 15 years of age using a growth-curve modeling approach it was found that the selective attention follows a logistic growth and focused attention follows an exponential growth.[3] There were significant differences in performance between 8–12 years and at 15 years of age. Findings from the present study indicate that children in the Y group performed better in visual search tasks and attention assessment (focused) parameters (TMT-A & B) with a P-value <0.0001 in comparison with the NY group (P=0.0260) indicating a better level of conjugation search and attention shift in the Y group. It is likely that the children in the Y group were able to manage interference by inhibiting irrelevant stimuli and focusing on specific stimuli, resulting in better performance in visual search and focused attention parameters in comparison with the NY group.

The digits forward and digits backward components of the digit span test have been found to be differentially predictive of attention, executive function, and behavior rating measures. Results suggest that digits backward is associated with attention and executive function processes.[9] Based on this study, digit span was taken as a measurement of auditory attention and verbal memory. Improvement of alerting and orienting networks, which enable readiness to respond to a target following a stimulus and focus on endogenous orienting, are probably the key factors responsible for improvement in attention and verbal memory in the Y group. The yoga program might have helped students by (a) aiding them to feel calm and focused, (b) giving them strategies to control their behavior in stressful situations, and (c) supporting positive self-esteem.

The findings of this study reveal that the participant students who were trained with a yoga module performed better in the TMT-A and TMT-B test, Stroop test, and digit memory test than those who did not experience the yoga module. The statistically significant results of the present study are in tune with the earlier studies, which found that meditation practiced over long periods produce definite changes in perception, attention, and cognition.[26] Yoga techniques are known to help in anxiety management and to enhance concentration[27] as well as improving self-confidence, social confidence, communication, and contribution in the class.[28] This might be one of the reasons for the better performance of the yoga-practicing group, as they are able to manage anxiety better than their non-yoga counterparts.

It is unlikely that the educational standard and methods of teaching have considerable influence on the results of the study, as the samples selected were from the same school with all the students receiving the same teaching methods. Also, the students were from the same socio-economic background, which was determined based on the

average parental income, and the influence of which on the scores of the study between the groups is unlikely. The influence of motivation and involvement as potential confounders resulting in better performance by students in the Y group is not considerable as the children themselves are not making a choice to learn and practice yoga but the parents.

Yoga programs incorporated as school-based interventions may help prevent behavioral problems, improve social participation, and help students to engage in classroom learning.[29] Research has also demonstrated that high levels of stress can lead to hyper-vigilance (inability to focus attention) and arriving at a solution too quickly (premature closure).[30] Stress overloads our mental and physical resources and interferes with the effective use of our skills, and thus, impacts negatively on the performance.[26] This study showed that practicing yoga regularly may help students relax and improve the effective utilization of their skills as evidenced in better selective attention in the yoga group.

LIMITATIONS AND RECOMMENDATIONS

Although this cross-sectional study provides observational evidence for better results in attention tasks and verbal memory in the Y group, it has several potential limitations, such as confounding factors and lack of a randomly distributed exposure. These issues may decrease the generalizability of our results. Despite adjustment for multiple potential covariates, there may still be residual confounding that might have contributed to the observed differences in outcomes. Moreover, our cohort was from a single institution and not a multi-center trial with a larger sample, which further impacts the generalizability of findings to some extent. These issues will need to be addressed by future studies in order to replicate and extend our findings.

CONCLUSIONS

It may be concluded from the present study that pre-adolescent school students who practiced yoga (yogic breathing and postures) in the previous 12 months showed better performance in visual attention, attention span, and verbal memory tasks compared with the pre-adolescent controls. Practice of yoga (postures and yogic breathing) improves memory, reduces anxiety levels,[18] improve self-confidence,[28] and brings positive changes in the perception of students, possibly leading to improvement in attention and memory if practiced consistently. Larger randomized controlled trials are needed to validate these findings.

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DISCLOSURE OF INTERESTS

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