



## ASSESSMENT OF COGNITIVE PERFORMANCE IN PRACTITIONERS OF SHORT AND LONG TERM RAJAYOGA MEDITATION.

### Physiology

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### ABSTRACT

**Background:** Rajayoga meditation (RYM) has demonstrable effects on psychological health and cognitive performance of an individual. **Objectives:** The present study was conducted to elucidate the influence of short and long term RYM practice on cognitive performance of an individual and to ascertain gender differences. **Materials and Methods:** 60 participants were divided into three equal groups on basis of duration of RYM; non-meditators (Group I), short-term meditators (Group II-6 months-5 years) and long-term meditators (Group III->5 years). Cognitive performance was assessed using a neuropsychological test battery. Results: Group III participants took significantly less time to complete TMTB ( $p=0.002$ ) and LCT ( $p<0.001$ ) as compared to group I participants. Males took significantly more time to complete LCT ( $p=0.010$ ) but were able to recall more on Forward Digit Span ( $p=0.004$ ) as compared to females. **Conclusions:** Variability in cognitive performance was seen across the meditators and non-meditators and amongst the two genders, as indexed by neuropsychological tests findings. Short-term meditators had better verbal recall whereas, long-term meditators exhibited better attention and executive functions. Young and middle-aged people can practice RYM to have better cognition as well as, to delay the age related decline in cognitive functions.

### KEYWORDS

Cognitive performance, Rajayoga meditation, working memory.

### Introduction

Meditation refers to a practice of focusing one's mind for a period of time on a single thing. It could be practiced by giving sustained attention to either one's own breath or body sensation, by visualizing a scene or by focusing on a sound, movement or an object. Meditation is simply a mental training to secure and enhance harmony between the physical, mental, emotional and spiritual aspects of an individual. A number of recent studies have shown significant effect of both regular as well as short term meditation training on cognitive skills and brain function.<sup>1</sup> Specific cognitive domains like alertness, perception, working memory, and decision making have been consistently found to be benefited by long term meditation.<sup>2,3</sup> However, studies of short term meditation have yielded inconsistent results on neuro-behavioral and executive functions.<sup>4</sup> Even less is known regarding the aspects of cognition that are influenced by Rajayoga meditation. Rajayoga is one of the techniques of meditation based on encouraging positive thinking, thus using the mind in a natural way. This type of mindful meditation involves awareness of self as a peaceful soul, which in turn, is instrumental in finding the path for relishing the blissful experiences that lie within one.<sup>5</sup>

There is ample evidence to show that various aspects of cognitive and executive function like planning, organization and mental flexibility as well as memory, get compromised with advancing age and this progressive decline, in turn, may lead to social withdrawal and depression.<sup>6</sup> Many studies have shown positive and demonstrable effects of different forms of meditation on psychological health and cognitive performance of an individual.<sup>7</sup> Some of the researchers working in the field of preventive medicine have even postulated that by enhancing the constructive states of mind, mental illnesses could be minimized, thereby, promoting psychological wellbeing and better cognitive status in an individual.<sup>8</sup> However, very little scientific research has been done to demonstrate the impact of Rajayoga meditation on cognitive status of middle aged individuals. The aim of the present study was to find out the effects of practice of short term and long term Rajayoga meditation on cognitive performance and memory in middle aged people and to ascertain the gender difference.

### Methods

The present study was a cross sectional observational study, carried out in the Department of Physiology, Maulana Azad Medical College, New Delhi. Before commencement, the project was duly approved by the ethics committee of the institution.

### Study groups

Total 60 participants with age ranging from 35 to 60 years were categorized into three groups of 20 each on the basis of duration of meditation.<sup>9</sup>

Group I included 12 male and 8 female participants who did not perform any technique of meditation and were selected from general population.

Group II included 10 male and 10 female participants who performed Rajayoga meditation for more than 6 months up to 5 years.

Group III in comparison included 8 male and 12 female participants who performed Rajayoga meditation for more than 5 years.

The meditating participants who regularly practiced Rajayoga meditation for 1 hour on all days a week were selected from Rajayoga meditation centre, Dwarka, New Delhi and were belonging to the same age group. They all were literate and had similar dietary habits, ethnicity and socioeconomic status as non-meditating group.

### Inclusion & Exclusion

Inclusion of the individuals in the age group of 35-60 years and having normal vision (with or without spectacles) as well as hearing was done in the study. Participants having history of substance abuse, alcoholism, smoking, acoustic handicap, visual handicap, patients with Alzheimer's disease/ Dementia/ Parkinsonism/ any other neurological illness, individuals practicing any other kind of relaxation or meditation technique were excluded from the study.

### Study protocol

The participants were asked to report for the study in the Rajayoga meditation centre in the morning hours. All the participants were given detailed information about the project and written informed consent was obtained from every participant of the study.

After taking a detailed history including history of meditation, a complete general physical examination was carried out in day light. Anthropometric parameters like height and weight were measured and body mass index (BMI) was calculated. After anthropometric measurements, all the participants were subjected to a complete battery of neuropsychological evaluation for cognition.

Neuropsychological test tool The paper based version of the tests were administered and scored as per the standard manuals. In order to facilitate replication, only tests available and frequently documented were employed.

### Trail making test (TMT)<sup>10</sup>

- This test is used as a measure of cognitive flexibility.<sup>11</sup>
- It is used to assess both sustained attention and task alteration abilities.

- Trail-B test was preceded by Trail-A test and a stopwatch was used as a time recording machine for recording the completion times of the two trails separately.
- The error correction time was included in the completion times.

**Part A**

- Assesses visuo-motor speed and attention.<sup>12</sup>
- The participant was instructed to connect 25 numbered circles in consecutive order
- The score was the time taken in seconds by the participant to complete the task.

**Part B**

- In addition to visuo-motor speed and attention, this requires the participant to shift strategy and hence is a sensitive measure of executive function.
- In this, the participant was instructed to connect number 1 and letter A followed by number 2 and letter B continuing in such a way that participant connects 25 numbered and lettered circles by alternating between the two sequences.
- The score was the total time taken in seconds by the participant to complete the task.
- **Letter cancellation test (LCT)**<sup>13</sup>
- This test assesses visual scanning, response speed and sustained attention.<sup>14</sup>
- The participant was presented with capital letters of the English alphabet arranged randomly in a structured pattern of 6 rows and 52 columns in which the target characters were randomly interspersed approximately 18 times in each row.
- The participant was instructed to cancel the two target letters, 'C' and 'E' as fast as possible. They were also told that they could follow the vertical, horizontal or random path according to their choice.
- The score was the time taken in seconds by the participant to actually perform this task.

**Omissions**

- The total number of C's and E's which were missed by a participant were noted.
- **Commissions**
- The total numbers of wrong cancellations were also noted.
- Test of working memory: digit span<sup>6,15</sup>

**Forward digits span(FDS)**

- It assesses immediate verbal memory span.
- In the test, participant was asked to repeat back sequences of digits of increasing length read out by the examiner.
- The score was the maximum number of digits that the participant could recall.

**Reverse digits span (RDS)**

- In addition to auditory attention and short-term retentive capacity this test also assesses the ability to manipulate information in the verbal working memory and hence is a sensitive measure of executive function.
- In this test the participant had to repeat the sequences of numbers of increasing digit length in reverse order to what was said by the examiner.
- The score was the maximum number of such digits that the participant was able to reverse.

**Data analysis:** The data was analyzed using SPSS 20 software (Inc., Chicago, Illinois, USA). Descriptive statistics in the form of mean±standard deviation (SD) was calculated for all observations. A two way MANOVA was conducted with gender and duration of meditation as independent variables and neuropsychological tests scores as dependant variables. This was followed up by univariate analysis of variance. Post hoc Bonferroni tests were applied for gender and duration. A p value<0.05 was considered statistically significant.

**Results**

All the three study groups were comparable with no statistically significant difference observed in mean of age, height, weight and BMI of the subjects in them. (Table 1)

A two way MANOVA was conducted with gender and duration of meditation as independent variables and neuropsychological tests scores as dependant variables. The omnibus analysis for the

neuropsychological tests revealed significant main effects of gender, F (7, 47) = 2.88, Wilk's  $\lambda$  = 0.700, partial  $\eta^2$  = 0.30, p= 0.014. In addition, main effects of duration of meditation were also observed, F (14, 94) = 4.48, Wilk's  $\lambda$  = 0.360, partial  $\eta^2$  = 0.400, p= <0.001. However, these analysis were superseded by a two way interaction effect of gender and duration of meditation, F (14, 94) = 2.63, Wilk's  $\lambda$  = 0.516, partial  $\eta^2$  = 0.281, p=0.003.

Decomposition of the gender and duration of meditation interaction examined the test within neuropsychological battery and revealed significant difference between TMT A score F (2, 53) = 6.76, partial  $\eta^2$  = 0.203, p= 0.002; LCT Time F (2, 53) = 6.17, partial  $\eta^2$  = 0.189, p= 0.004 and LCT omission F (2, 53) = 4.23, partial  $\eta^2$  = 0.138, p=0.020. Post hoc Bonferroni tests indicated that participants in group III took significantly less time to complete TMT B (p= 0.002) and LCT (p= <0.001) as compared to group I participants. (Table 2)

Univariate ANOVA with Bonferroni corrections further indicated that males took significantly more time to complete LCT (p= 0.010) as compared to females. They also were able to recall more as compared to females as revealed by FDS data (p=0.004). (Table 3)

**Table 1:** Distribution of age and anthropometric measurements of subjects in the three study groups (n=20 in each group). Values are Mean±SD.

Variable	Group I (n=20)	Group II (n=20)	Group III (n=20)	ANOVA (p)
Age(years)	45.75±9.23	42.80±7.54	44.25±6.84	0.505
Height( cms)	160.50±8.56	161.20±9.04	162.00±4.28	0.823
Weight(kgs)	67.13±10.42	65.45±11.42	67.88±12.36	0.791
BMI(kg/m2)	26.04±3.40	25.16±3.42	25.77±3.96	0.731

**Table 2:** Descriptive statistics and intergroup comparisons of neuropsychological test scores in the three study groups (n=20 in each group). Values are Mean±SD.

Groups Tests	Group I (n= 20)	Group II (n=20)	Group III (n=20)	ANOVA (p)	Intergroup comparison (p)
TMT A	91.55±23.49	92.60±24.15	88.10±18.45	0.799	NS‡‡ † ‡
TMT B	132.65±29.40	113.55±32.97	98.40±26.58	0.003*	NS‡‡ † ‡ p=0.001†
LCT TIME	115.15±32.04	101.95±22.73	67.60±8.96	0.112	p<0.001‡‡ † ‡
OMISSION	3.20±2.02	3.95±1.88	3.55±1.23	0.401	NS‡‡ † ‡
COMMISSION	0.20±0.41	0.00±0.00	0.10±0.31	<0.001*	NS‡‡ † ‡
FDS	6.20±1.28	6.45±1.50	5.75±0.85	0.205	NS‡‡ † ‡
RDS	3.80±0.77	4.15±0.93	3.70±0.73	0.196	NS‡‡ † ‡

TMT A, B – Trail making test A and B; LCT – Letter cancellation test; FDS – Forward digit span; RDS – Reverse digit span

\*-Significant; \*\*- very significant

‡‡ = Group I versus Group II; † = Group I versus Group III; ‡ = Group II versus Group III

**TABLE 3:** Gender based differences in neuropsychological test scores. (Male:Female=30:30)

Variable	Mean difference (Male – Female)	Standard Error	F Value	Partial $\eta^2$	P Value
TMT A	1.48	5.33	0.077	0.001	0.782
TMT B	-7.90	7.74	1.04	0.19	0.312
LCT TIME	14.34	5.37	7.13	0.117	0.01**
LCT OMISSION	-0.01	0.44	0	0	0.99
LCT COMMISSION	0.06	0.08	0.521	0.01	0.473
FDS	0.89	0.30	8.711	0.139	0.005*
RDS	0.22	0.21	1.098	0.02	0.299

TMT A, B – Trail making test A and B; LCT – Letter cancellation test; FDS – Forward digit span; RDS – Reverse digit span

\*- significant, \*\* - very significant

## Discussion

In the current study, we investigated the influence of short and long term Rajayoga meditation on cognitive performance in middle aged people using a battery of neuropsychological tests. The tests used in the study are measures of performance of various cognitive domains like visuo – motor speed and attention (TMT A), decision making and cognitive flexibility (TMT B and LCT) as well as immediate recall (FDS and RDS). Systematic administration of these tests provided us a fair insight into cognitive status of participants in the three groups.

Our data illustrated significant main effects of both the duration of meditation ( $p < 0.001$ ) and gender ( $p < 0.05$ ) in the participants. This was superseded by a two way interaction effect between the two independent variables in the study. These effects suggest that our experimental model was effective and that we could reliably measure even small differences in cognitive performance amongst the participants in various groups.

The data of the present study showed variability in performance across the meditators and non – meditators. The findings further demonstrated that different duration of practicing Rajayoga meditation also had variable influences amongst the two meditation groups for different neuropsychological tests. Results of Trail making and Letter cancellation tests reveal that long term meditation practitioners had better visuo-motor speed, attention, problem solving and cognitive flexibility skills as they were able to perform both TMT B and LCT significantly faster ( $p < 0.001$ ) as compared to short term meditation practitioners and non meditating group. The magnitude of the errors incurred by the participants in performing LCT task did not differ between the three groups. The mean number of omissions was less in long term meditators but their mean number of commissions was more as compared to the short term meditators. However, non meditators omitted less as compared to both type of meditators in performing LCT. In contrast to this, the short term meditators were found to have better working memory as compared to the other two groups as indicated by the FDS and RDS data. Group II participants were able to recall more number of digits in both these tests, thereby suggesting that even less duration of meditation could have a beneficial role in enhancing the retention capacity of an individual and enable better manipulation of verbal information. This finding is consistent with prior research that meditation training of short duration significantly improved visuo-spatial processing, working memory and executive functioning, short term memory and cognitive flexibility scores.<sup>16,17</sup> Another study indicated that mindfulness training may not necessarily lead to enhanced internal attention, switching capacity but may significantly benefit working memory capacity and sustained attention.<sup>18</sup> In contrast another study showed no influence of meditation practice in social cognition measures like emotion recognition and empathy task that revealed lower accuracy performance in LTM group than controls.<sup>19</sup>

Long term meditation practice is associated with increased cortical thickness in subjects who practice insight meditation, which involves focused attention on internal experience. Prefrontal cortex, right anterior insular areas, cingulate cortex, hippocampus, orbito-frontal and frontal cortex and the brainstem associated with attention, interception and sensory processing were thicker in meditators than matched non meditators.<sup>7,20</sup> Meditation practices lead to morphological alterations in both gray matter and white matter due to changes in both myelination and axonal structures of neurons as new connections are formed between commissural and association tracts. It could be due to increased cerebral blood flow to the brain while practicing meditation over a long duration. This explains the ability of meditators for having better executive function, problem solving and decision making.<sup>21</sup>

The variability in cognitive performance was also evident across the two genders in our study. Our neuropsychological data further indicates that females had better attention span, decision making and executive functions as compared to males whereas males had better working memory and recall ability as indexed by FDS and RDS. This finding is in concurrence with a study that suggested meditation effects differed between men and women in magnitude, laterality, and location on the hippocampus surface.<sup>9,21,22</sup> Another investigator studied

interaction between meditation and gender and suggested that both male and female were equally benefited from meditation.<sup>23</sup>

Such sex-divergent findings may be due to genetic (innate) or acquired differences between male and female brains in the areas involved in meditation and/or suggest that male and female hippocampi are differently receptive to mindfulness practices or it could be due to activation of different neural substrates which could possibly overlap and differ along with gender.

These are important findings as Rajayoga meditation could serve as an adjunctive technique to improve cognitive functions in middle age and prevent or delay cognitive decline in old age. However, it would be imprudent to extrapolate these findings to general population before further statistical validation.

## Conclusion

The data of the present study showed that practice of both short term as well as long term Rajayoga meditation had positive influence on cognitive performance of middle age individuals as compared to those who did not practice Rajayoga meditation. Variability in cognitive performance was seen across the meditators and non meditators as well as amongst the two gender, as indexed by the findings of different neuropsychological tests. Short term meditators had better working memory and recall whereas, long term meditators had comparatively better visuo-motor speed, attention and cognitive flexibility functions. Hence, this form of meditation can be practiced by young and middle aged people to have better cognitive functions in late life as well as to delay the age related decline in cognition.

## Limitations

The small sample size was the limiting factor which could be increased in future studies.

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