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Effect of Sudarsankriya yoga practices on P300 amplitude and latency

Ashwini PR Gholam
Rajesh Ranjan*
Jayashree S Bhat

ABSTRACT

The cognitive ability which was perceived as a constant trait, is now understood to be upgraded by adaptive and extended training. Yoga practices are known to sharpen the intellect and enhance concentration. In the initial period of practicing yoga as an alternative/ supporting tool to medical line of treatment, it is essential to investigate effect of yoga on cognitive ability using objective method, in order to establish evidences. Hence, aim of this study was to explore the effect of regular practice of sudarsankriya yoga on auditory event related potential (P300) by recording and comparing peak latency and amplitude. The participants were divided into three groups with Group I and Group II participants practicing sudarsankriya yoga for more than 36 months and less than 36 months respectively. Group III were non-practitioners with no prior practice of any form of yoga. Twenty participants in each group with a total of 60 participants between 40 to 65 years of age were recruited for the study. Results revealed a significant difference for mean latency and amplitude between three groups. Findings of the current study suggest that sudarsankriya yoga practices slows down the process of aging effect or maintains on cognitive ability in adults.

Keywords: Sudarsankriya yoga, P300, Peak latency and amplitude, Aging

Department of Audiology and Speech Language Pathology, Kasturba Medical College, MAHE, Mangalore, Karnataka, India

*Send correspondence to:
Rajesh Ranjan,
Department of Audiology and Speech Language Pathology, Kasturba Medical College, MAHE, Mangalore, Karnataka, India, E-mail: rajesh.ranjan@manipal.edu
Phone: +98543 322 4991
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INTRODUCTION

The yoga is a mental, physical and spiritual activity, widely practiced as exercise or alternative medicine. Yoga sharpens the intellect and enhances the concentration. Apart from achieving physical health through breathing techniques and postures, it aims mental health ability to maintain cognitive functions, specifically in the area of memory, attention and arousal control[1]. There are studies indicating the influence of yoga on memory and attention. Among popular form of yoga practices sudarsankriya yoga (SKY) practices is well known to improve on cognitive ability[2]. In SKY, cylindrical controlled breathing is practiced, which comprises of 4 distinct consecutive segments separated by 30 second periods of normal breathing. The slow breathing per minute of 3 cycles is initially practiced under Ujjayi, then 20-30 cycles of rapid exhalations per minute is practiced known as bhasrika. Following this, Om chanting with prolonged expiration, and sudharsankriya-slow, medium, and fast cycles of rhythmic breathing is practiced. The effect of yoga on cognition have been evaluated with behavioral examinations, survey/interview and objective (neurological-fMRI, EEGs, ERPs etc.,) methodologies, and each one of them has been useful in elucidating some of the ways in which yoga impacts on cognition. Cognition is a mental process required to acquire knowledge, and understand it via senses and perception. Cognition involves various processes such as memory, attention, language, reasoning, which is required for day to day functioning. One of recent trends to measure cognition ability objectively is event related potentials (ERPs). The P300 ERP is highly sensitive to the cognitive changes. The cognitive and mnemonic functions in humans are reported to be reflected in P300, a late cortical neurophysiological event, which is strongly linked to attention and short term memory[3]. Cognitive abilities are essential for making plans, solving problem, and learning new skills. At present, available literature indicates that cognitive decline can appear at younger age, and continues further with aging, which impairs the quality of life in aging individuals. This cognitive ability which was considered as a constant trait, is now viewed to be capable of upgrading by adaptive and extended training[4] . Yoga practices are known to sharpen the intellect and enhance concentration. Some researchers have investigated the effect of yoga on cognitive ability either by behaviors measures or by deriving P300, which is not conclusive enough to draw any conclusion. In the developing period of using Yoga as an alternative tool of medicine, it is essential to investigate the effect of yoga on cognitive ability using objective method, which yields results that are more reliable. Hence, aim of the study was to investigate the effect of regular practice of SKY on auditory event related potential (P300) by recording and comparing peak latency and amplitude of P300 in SKY practitioners and non-practitioners.

METHODS

Participants between 40 to 65 years of age participated in the study. Three groups of participants were considered, Group I had participants practicing SKY for more than 36 months, Group II consisted participants practicing SKY for less than 36 months and Group III had non-practitioners with no prior practice of any form of yoga. Twenty participants in each group with total of 60 participants were included in the study. Group I (Male= 11, Female= 9; Mean age= 49.55years, SD= 11.10) consisted of participants practicing SKY for more than 3 years; Group II (Male= 11, Female= 9; Mean age= 49.70years, SD= 10.85) consisted participants practicing SKY for less than 3 years (ranging between 6mths to 36 months); and Group III (Male= 11, Female= 9; Mean age=49.35years, SD=11.13) involved non-practitioners. None of the participants reported exposure to loud noise, usage of ototoxic drugs, presence or history of ear discharge, alcohol dependency, sensory and processing deficits, or any other circulatory, renal, psychological, medical and neurological issues. All the participants were graduates and employed, with right handedness[5]. All the tests were carried out in a sound treated room, with noise levels within the permissible limits[6] Procedure: Initially demographic data was collected from all the participants to ensure eligibility criteria. Subsequently Mini Mental State Examination (MMSE) was administered for all the participants. The MMSE[7] is a 30-point questionnaire consisting 11 questions concerning various cognitive functions such as orientation, registration, attention and calculation, language and recall. Participants having score more than 26 were considered for the study[8]. The participants were evaluated for handiness and hearing as per Oldfield, 1971 and WHO classification respectively. The Auditory Event related potentials (P300) were recorded using speech oddball paradigm for the participants who met the selection criteria.

Electrophysiological testing:

Stimuli : Two speech sounds /da/ and /ba/ of a native female Kannada speaker was recorded using Multidimensional Voice Program (MDVP) software (version 3.2.0) with standard microphone attached to that. Normalization was done using PRAAT software. Normalized stimulus was uploaded in E-prime software (version 2.0) to run oddball paradigm task. The stimuli were presented at 70dBSPL via inserts (ER-3A) to right ear. 80% of the stimuli were standard (/ba/) occurring frequently and 20% were infrequent target (/da/) stimuli. A total of 300 stimuli were presented having an inter stimulus interval of 1.5 second.

Participant preparation: Continuous EEG was recorded with an Electrical Geodesics Inc (NetStation 5.2) 64 channel system with a sampling rate of 250 Hz and impedance was monitored throughout the recording and kept below 50 kΩ. The distance located at 50% of the total length between nasion to inion and between

both zygomatic notches was marked as the midpoint CZ (vertex point). The sensor net size was determined by head circumference and electrode cap was dipped in the saline solution of distilled water, potassium chloride and baby shampoo, five minutes prior to placement to facilitate a connection between each of the electrodes and the scalp (Table 1).

Test procedure: The participants were seated comfortably and electrode cap was placed. Participants were then instructed to relax and remain alert throughout the testing along with their eyes open. ER-3A inserts were placed in participant's ear and the stimuli were presented through the inserts. Initially practice trial was given. Later, a maximum of 300 trials were presented. Participants were instructed to press the key immediately on hearing the infrequent target stimuli (/da/) in a series of frequent stimulus (/ba/) presented and to keep a count. At the end of the recording, they were asked to report the number of stimuli counted. This was done in order to ensure that the participants were attentive to the stimuli, and these were not used for any analysis. Waveform of both frequent and infrequent stimulus was recorded from electrode sites. Responses were saved to analyze offline.

Offline analysis: The EEG was analyzed offline using NetStation tool box (version 5.2). The raw recordings were filtered with a low pass frequency of 30Hz and a high pass filter of 0.1Hz. The continuous filtered recordings were segmented into epochs from the 100ms before the onset to (baseline) to 1,200 ms after the onset of the first note. The artifacts which distort the ERP waveform were removed automatically based on the specified parameters (Bad Channels: greater than 100μv activity in a 640ms window with performing moving average of 80ms; Eye Blink: greater than 50μv for 640ms window; Eye Movement: greater than 55μv for 1000ms window), and segments were rejected if more than 10 channels were identified as bad channels. After artifact removal, for each participant, bad channels were identified and were replaced with remaining channels in 'good' segments by interpolating them. Single average data were collected for the remaining segments that were not rejected with the specification to handle source file and subjects separately. EEG was analyzed with referenced to an average of the mastoid. Later, the 100ms pre-stimulus period was used for baseline correction.

Statistical analysis: The data was subjected to statistical analysis using SPSS software (version 16.0). Repeated measures ANOVA and Post hoc tests were done to find the significance ($p \leq 0.05$) of difference between the groups for peak amplitude and latencies at each electrode sites.

RESULTS

Effect of SKY on peak latency of P300 across the Electrode sites

A notable difference was observed on comparing the mean latencies between three groups. In comparison of mean latencies of participants practicing SKY for less than 36 months (Group II) and non-practitioners, the mean latencies of participants practicing SKY for more than 36 months (Group) was distinguishably less. Furthermore, it can be observed that the mean latencies of parietal electrode sites (Pz, P1 and P2) is increased when compared with mean latencies of frontal electrode sites (Fz, F1 and F2) in all three groups and this has been represented in (Figure 1). To investigate the effect of group on latency of P300 across the electrode sites, repeated measure ANOVA was performed with electrode as repeated measure or within subject variable and group as between subject measure. A repeated measure ANOVA with Greenhouse-Geisser correction showed a significant effect [F (2.06, 117.775$=$7.85), $p=0.001$] of electrode sites on latency of P300, there was no effect [F (2, 57$=$37.20), $p=0.13$] of group on latency of P300,

Table 1: Parameters were used to elicit auditory P300 response.

Parameters		
Subjects	State	Awake and quite
	Eyes	Eye open
	Conditions	Attend
Stimuli	Type of stimuli	Speech (oddball paradigm)
	Inter onset interval	1.5s
	Intensity	70dBSPL
Recording	Save	Ongoing, continuous EEG.
	Electrodes	64 channels
	Reference electrode	Mastoid
	EEG filters	0.01-30Hz
	Analysis time	Pre stimulus-- 100ms Post stimulus- 1200ms
	Number of trials	300
	Replication	One
Measurements		P300 (Baseline to peak amplitude, peak latency)
Response presence	Determined by	If two audiologist mark same peak latency for P300 using double blind design.

and interaction between electrodes and groups was also not regime [F (4.13, 117.775=), p=0.47]. Pair wise comparison revealed a significant difference in P300 latency between Pz and Fz (p=0.021), Fz and P1 (p=0.005), Fz and P2 (p=0.007), P1 and F1 (p=0.021) as well as P2 and F2 (p=0.048). There was no significant difference in the latency between the other electrode sites. In general, the peak latency of frontal electrodes was significantly lower than parietal electrodes except for F2 electrode site.

Effect of SKY on peak amplitude of P300 across the Electrode sites

The results of descriptive statistics for peak amplitude of P300 for all three groups revealed that the highest mean amplitude at all the six electrode sites was noted for Group I. Mean amplitude of P300 at all the electrode sites were better for Group I and Group II, SKY practicing participants, than non-practitioners of Group III. Average group mean amplitude for all the electrode sites, Pz (M=7.63, SD=3.61) had highest mean peak amplitude followed by P1 (M=7.17, SD=3.48), Fz (M=7.12, SD=3.42), F2 (M=6.92, SD=3.10), F1 (M=6.88, SD=3.06) and P2 (M=6.78, SD=2.98). These differences are represented in the (Figure 2).

In order to understand the effect of SKY on amplitude of P300 across different electrode sites repeated measure ANOVA was done considering electrodes as within subject factor and groups as between subject factors respectively. Sphericity was tested using Mauchly's Test of Sphericity. Mauchly's Test indicated that the assumption of Sphericity had been violated (x2(14) =94.21, p<0.001). Greenhouse-Geisser correction was applied. Results revealed that there was a significant effect of electrodes [F (2.73, 155.64=2.95), p=0.013] and Groups [F (2, 57=37.20), p<0.001] on amplitude of P300. There was no significant [F (5.46, 155.64=0.89), p=0.25] interaction between groups and electrodes. Post hoc analysis using Bonferroni correction suggested that, there were significant differences present between all the groups (p<0.001) for amplitude parameter of P300. Overall, across these three groups, participants practicing SKY for more than 36 months (Group I) had significantly greater amplitude values followed by participants practicing SKY for less than 36 months (Group II) and non-practitioners (Group III) respectively. Pair wise comparison revealed a significant difference in p300 amplitude between Pz and P1 (p=0.027), Pz and P2 (p< 0.001), Pz F1 (p=0.01), Pz and F2 (p=0.013) P2 and F2 (p=0.048). There was no significant difference in the peak amplitude between the Pz and Fz (p=0.11) as well as between other electrode sites. Overall, Pz had significantly higher amplitude than other electrode sites.

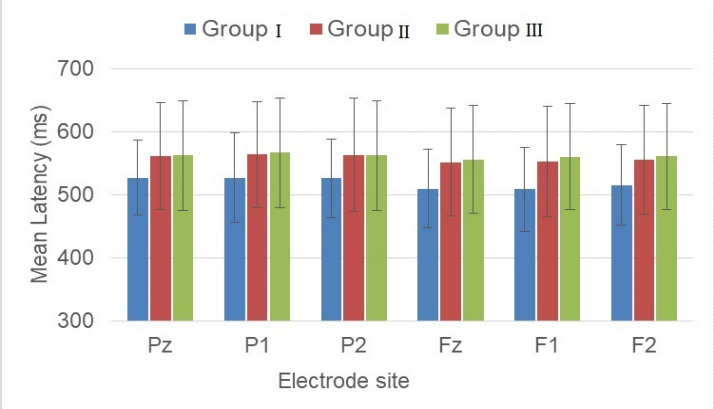

Figure 1: M± 1 SD of P300 latency at Pz, P1, P2, Fz, F1 and F2 electrode sites for all the three groups of participants (M- Mean, SD- Standard deviation).

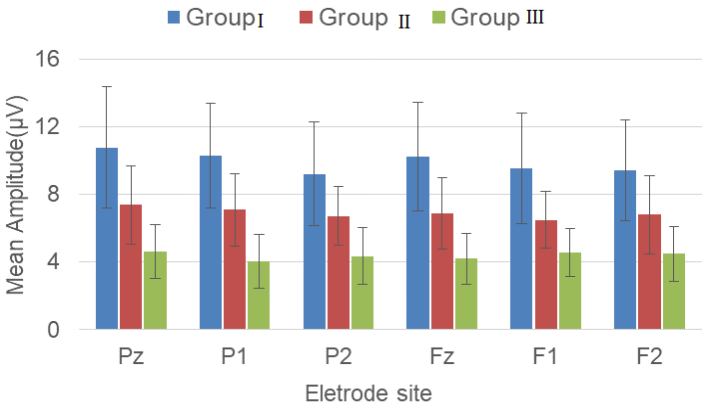

Figure 2: M± 1 SD of P300 amplitude at Pz, P1, P2, Fz, F1 and F2 electrode sites for all the three groups of participants (M- Mean, SD- Standard deviation).

DISCUSSION

Effect of SKY on Peak latencies of P300

In the present research, results revealed that long term SKY practitioners had significantly reduced latency in comparison to other two groups. The Latency of P300 specifies the speed of conduction required to analyse the target stimuli presented in between the chain of standard stimuli and update working memory regarding the change. Hence in the present study, speed of conduction of stimuli were better in SKY practicing groups which indicate better ability, that can be associated with improved blood circulation to the auditory system leading to improvement in physiological function. However Group II did not show significant difference with Group III for the latency parameter, though the differences were noted in raw mean scores. This reduced difference between Group II and Group III could be due to duration and intensity of practice, suggesting that improvement on latency or processing speed requires more duration or intense practices. Hence, present study indicates that longer SKY practices can slow down the decay in speed of conduction processing ability. The present finding is in accordance with some investigators[9-11]. Within subjects at different electrode sites, it is noted that frontal electrode sites (FZ & F1) had improved latency than parietal electrode sites, which could be due to the age range of the participants taken for the study (40 to 65 years). Generally, with increase in age, latency of P300 will prolong more in parietal region[12] and the prolongation noted in frontal region is less. Thus, the results obtained in the present study are in agreement with previous findings and will also demonstrate age as a confounding variable and its effect on peak latency of P300.

Effect of SKY on Peak amplitude of P300

In present study, SKY doing participants had significantly higher peak amplitude values than non-practitioners. These findings suggest higher neuronal activities in SKY practicing participants, which can be attributed to better cerebral blood flow and improved oxygenation level in blood leading to improved physiological function or better processing of the task related stimuli. The peak amplitude of P300 is linked to amount of neuronal activity and these changes in neuronal activity are associated with increased cerebral blood flow[12] . Yoga is also known to improve cognitive abilities such as attention, working memory ability, and other cognitive functions and these cognitive abilities are reflected on P300 amplitude. The improved cognitive ability and increased amplitude values of P300 following yoga practices have been reported[13-15]. The finding of present study can also be attributed to anatomical change in the brain due to longer duration of SKY practices. The evidences suggest neuroanatomical changes that underlie yoga related to attentional processing. The decrease in thickness of grey matter, most significantly in putamen, the structure required for allocating attention and its processing[16] improvement in myelination and increase in the strength of circuits like association pathways, commissural pathways, and projection pathways in the brain[17] increased brain perfusion in the areas of auditory cortex, prefrontal cortex[18] and increase in functional areas of processing attention[19] facilitates the activities of higher cognitive processes.

In the present study, two groups of participants were practicing SKY, Group I for more than 36 months and Group II were practicing for lesser than 36 months. Both the groups had significantly higher peak amplitude of P300 compared to non-practicing Group III. Moreover, between Groups I and Group II, Group I had higher amplitude which could be attributed to duration of SKY practices. The longer the duration of SKY practices, higher is the peak amplitude value. From present finding, it can inferred that SKY practices not only keeps cognitive system intact but also improves the physiological ability of the brain. It also slows down the process of aging effect on cognitive ability. Hence, SKY practices can be useful to maintain cognitive ability, to slow down ageing process, so that quality of life remains good. The similar study of intensity and duration effect of yoga over cognitive processing has been reported by several investigators[20-22]. The significantly greater amplitude of P300 in midline electrodes (Pz & Fz) than lateral electrodes noted in present study is consistent with the previous reports done using pure tone oddball paradigm [24] and this difference between midline and lateral electrode may be due to the contribution of amount of current flow due to variation in cellular volume, scull density, and width under the electrode sites[24,25] .

CONCLUSION

From present finding it can inferred that SKY practices not only keeps cognitive system intact but also improves the physiological ability of brain. Hence SKY can be suggested as an alternative medicine to maintain cognitive ability, to slow down ageing process to ensure good quality of life.

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REFERENCES

1. Nangia D, Malhotra R. Yoga, cognition and mental health. Journal of the Indian Academy of Applied Psychology, J. Indian Acad. Appl. Psychol. 2012;38:262-9.
2. Bhatia M. Electrophysiologic evaluation of Sudarshan Kriya: an EEG, BAER, P300 study," Indian J. Physiol. Pharmacol. 2003;47:157-63.
3. Polich J, Howard L, Starr A. UC Irvine UC Irvine Previously Published Works Title P300 Latency Correlates with Digit Span. Psychophysiology. 1983;20: 665-9.
4. Klingberg T. Training and plasticity of working memory. Trends Cogn. Sci. 2010;14:317-24.
5. Oldfield RC. The assessment and analysis of handedness: The Edinburgh inventory, Neuropsychologia. 1971;9:97-113.

6. American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound-Part 4: Noise Assessment and Prediction of Long-term Community Response. 2005.

7. Folstein MF, Folstein SE, McHugh PR. Mini-mental state. A practical method for grading the cognitive state of patients for the clinician J. Psychiatr. Res. 1975; 12:189-98.

8. D'cruz SM, Rajaratnam N. The effect of Aging on cognitive function in a South Indian population, Int. J. Sci. Res. Publ. 2013;3:1-5.

9. Joshi M, Telles S. A Nonrandomized Non-Naive Comparative Study of the Effects of Kapalabhati and Breath Awareness on Event-Related Potentials in Trained Yoga Practitioners. J. Altern. Complement. Med. 2009;15:281-85.

10. Sarang SP, Telles S. Changes in p300 following two yoga-based relaxation techniques, Int. J. Neurosci. 2006;116:1419-1430.

11. Travis F, Miskov S. Electro physiological and EEG changes : P300 latency and Amplitude during eyes-closed, rest and transcedental meditation practice. psychophysical. 1994;31:S98.

12. Polich J. Updating P300: an integrative theory of P3a and P3b, Clin. Neurophysiol. 2007;118:2128-48.

13. Verma A, Shete SU, Thakur GS, Kulkarni DD, Bhogal RS. The Effect of Yoga Practices on Cognitive Development in Rural Residential School Children in India. Natl. J. Lab. Med. 2014;3:15-19.

14. Prakash RP, Rastogi I, Dubey S, Abhishek P, Chaudhury S, Small BJ. Long-term concentrative meditation and cognitive performance among older adults. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn. 2012;19:479-94.

15. Van Leeuwen SN, Müller G, Melloni L. Age effects on attentional blink performance in meditation. Conscious. Cogn. 2009;18:593-99.

16. Pagnoni G, Cekic M. Age effects on gray matter volume and attentional performance in Zen meditation. Neurobiol. Aging. 2007;28:1623-27.

17. Luders E, Clark K, Narr KL, Toga AW. Enhanced brain connectivity in long-term meditation practitioners. Neuroimage. 2011;57:1308-16.

18. Newberg A, Alavi A, Baime M, Pourdehnad M, Santanna J, Aquili E. The measurement of regional cerebral blood flow during the complex cognitive task of meditation: a preliminary SPECT study. Psychiatry Res. 2001;106:113-22.

19. Lazar SW, Kerr CE, Wasserman RH, Gray JR, Greve DN, Treadway MT, et al. Meditation experience is associated with increased cortical thickness. Neuroreport. 2005;16:1893-97.

20. Jiwtode MT, Mahajan M. Effect of duration of yoga training on pulmonary function tests and respiratory pressures in sedentary healthy adult population of Nagpur. Al ameen J. Med. Sci. 2016;9:78-83.

21. Ross A, Thomas S. The Health Benefits of Yoga and Exercise: A Review of Comparison Studies. J. Altern. Complement. Med. 2010;16:3-12.

22. Telles S, Pathak S, Kumar A, Mishra P, Balkrishna A. Influence of Intensity and Duration of Yoga on Anxiety and Depression Scores Associated with Chronic Illness. Ann. Med. Health Sci. Res. 2015;5:260-5.

23. Alexander JE, Bauer LO, Kuperman S, Connor SJO, Rohrbaugh J, Porjesz B, et al. Hemispheric differences for P300 amplitude from an auditory oddball task Short Communication. Int. J. Psychophysiol. ELSEVIER Int. J. Psychophysiol. 1996; 21:189-96.

24. Polich J, Alexander JE, Bauer LO, Kuperman S, Morzorati S, Connor SJO, et al. P300 Topography of Amplitude / Latency Correlations. Brain Topogr. 1997; 9:275-82.

25. Ford JM, Sullivan EV, Marsh L, White PM, Lim KO, Pfefferbaum A. The relationship between P300 amplitude and regional gray matter volumes depends upon the attentional system engaged. Electroencephalogr. Clin. Neurophysiol. 1994;90:214-228