Original Article

Effect of Early Yoga Practice on Post Stroke Cognitive Impairment

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Abstract

Background: Post-stroke cognitive impairment (PSCI) is a clinical entity that encompasses all types of cognitive impairment following an index stroke. Yoga has been proven to have a beneficial effect not only on cardiovascular risk factors but also on cognition. Hence, this study explored the PSCI spectrum and assessed the effect of yoga on PSCI. **Methods:** Forty stroke patients were enrolled in each yoga and control arm in this study. After the baseline assessment, control arm was administered standard care (including physiotherapy) while yoga arm received additional yoga intervention. Change in MoCA scores by 2 points in either direction, or FAB scale by 2 points at 6 months was taken as primary outcome, whereas improvement in MRS, CDPSS, CBS, and P300 values were considered as secondary outcomes. **Results:** Significant improvements were observed in MoCA, FAB, MRS, CPDSS, and CBS scores in both groups after 6 months. However, intergroup comparisons revealed better MoCA (25.5, IQR 22-27) and FAB scores (15.5, IQR 14-17) in yoga group compared to controls (24, IQR20-25.75) and (14, IQR12-15.75). Equivalent improvement was observed in MRS and CBS scores in both groups at 6 months; however, CDPSS score was better in yoga group ($p = 0.0008$). Both P300 amplitudes and latencies improved in all patients and median P300 amplitudes were significantly better in control group; however, no difference could be appreciated in P300 latencies improvement on intergroup comparisons at follow-up. **Conclusion:** Study reveals that early yoga intervention in stroke survivors leads to better improvement in cognitive abilities which would further facilitate in early reduction of caregiver burden.

Keywords: Caregiver Burden Scale, Clinician-Rated Dimensions of Psychosis Symptom Severity, Frontal Assessment Battery, Montreal Cognitive Assessment, post-stroke cognitive impairment, P300, yoga

Introduction

Research and interventions in stroke survivors have primarily been focused on physical disabilities, while research on cognitive disabilities due to stroke remains limited.[1] Post-stroke cognitive impairment (PSCI) is a clinical entity that encompasses all types of cognitive impairment following an index stroke. It may affect up to one-third of stroke survivors.[2]

Important structures of brain are connected by various association fibers. Volume of these connections involved in infarct is an important determinant of cognitive decline. However, brain has an enormous capacity for new synaptogenesis, neurogenesis, neuronal circuit rewiring as well as new circuit formation (neuroplasticity). Neuroplasticity is maximum during the initial phase of recovery post-stroke, and if intervened early, better outcomes may be obtained.

Yoga has been reported to have beneficial effect on traditional risk factors of stroke as well as cognitive functions.[3-5] Thus, a regular practice of yoga and meditation among the patients with stroke may help in improving the cognitive functions. Considering these facts, present study was done to evaluate the spectrum of PSCI, as well as to assess the effect of yoga on PSCI in ischemic stroke with a recent, within one month onset.

Materials and Methods

Design and ethics statement

It was a hospital-based open-label, randomized, control study conducted at a tertiary care center in central India. As it was a pilot study, a convenient sample size of 30 patients in each arm (yoga arm and control arm) was planned to be included. However, considering a drop-out rate of 25%, finally 40 patients were included in each arm. In accordance with the Declaration of Helsinki, all participants were recruited after obtaining approval from the Institutional Human Ethics Committee.

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Participants

Both male and female patients of ages >18 years with ischemic stroke onset within past 1 month, having a modified Rankin scale (MRS) ≤3, who presented either to emergency or outpatient department of neurology were included. Participants having pre-existing dementia or minimal cognitive impairment (MCI), or those already practicing yoga were excluded from the study. Patients having severe aphasia and/or severe dysarthria, cardiopulmonary contraindication for physical exercise as per the American College of Sports Medicine or suffering from any chronic disease with less than 2 years of life expectancy, contraindications to undergo magnitude resonance imaging (MRI) or for yoga/breathing exercise (major artery stenosis/dissection etc), residing >50 km from the research site or, pregnant or planning for pregnancy during the study period or denied consent for the study were excluded.

Randomization

Block random allocation of patients was done (with a block size of 4) in two groups (yoga arm, N = 40; and control arm, N = 40) using SPSS software. All the enrolled patients were assessed and treated as per standard of care, which included physiotherapy consultation.

Procedure

Standard tools like modified Rankin scale (MRS), Montreal Cognitive Assessment (MoCA), Frontal Assessment Battery (FAB), Clinician-Rated Dimensions of Psychosis Symptom Severity (CDPSS), and Caregiver Burden Scale (CBS) were used to assess the baseline status of the patients on different domains. All other investigations and brain MRI were done as per standard of care.

P300

Event-related potential (P300) was measured in neurology laboratory, as an objective neurophysiological method to assess cognition. P300 was recorded on neuropack-4-evoked potential machine (Nihon Kohden). Each participant was seated in a silent room, and electrodes were placed according to the standard international 10-20 system. Participants were made to wear headphone and listen attentively to the auditory stimuli being presented. Auditory odd-ball paradigm with pure tone stimuli was administered binaurally at an intensity of 70 dB SPL at a rate of 0.5 Hz. The target tone (20%) of 2000 Hz; 80 dB and non-target (80%) of 1000 Hz; 60 dB, were presented at random order of occurrence. Patients were asked to respond only to the infrequently presented target stimuli by pressing the switch provided to him. After smoothening, P300 latency values were recorded at the highest peak (i.e., maximum wave amplitude) of response curve.

Intervention- Hatha yoga

In the first week of intervention, patients were expected to attend yoga sessions for at least 5 days, to enable them to learn the asanas/breathing techniques. Each yoga session was of about 60 minutes, supervised by trained yoga teacher. This consisted of 5 minutes of breathing exercises, 10 minutes of strengthening exercises, 30 minutes of simple yoga asanas, 10 minutes of pranayama, and 5 minutes of meditation. On first session, a single 10-minute lecture on yoga concepts and possible benefits was described to all new enrolled patients in yoga group. Standard rehabilitation as per stroke disability was also offered to these patients along with yoga. Thereafter, for the next 11 weeks, the intervention was supervised via tele-yoga sessions with the help of recorded video telecast on Google Meet platform for at least 1–2 days a week. All patients were encouraged to continue practicing their respective rehabilitation activity for next 3 months with a frequency of at least 4–5 days/week at home [Figure 1]. Once-weekly reminders were provided to them with the help of text messages. Patients replied with a missed call or text message; and failure to do either of them was considered as

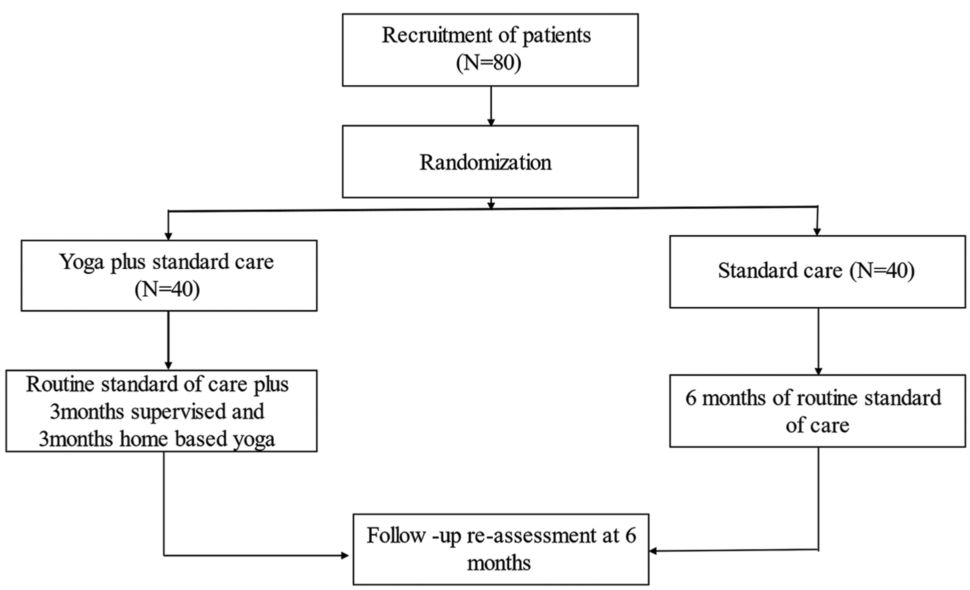

Figure 1: Workflow of the study

non-compliance. Patients in the control arm were advised to continue with physical activity at home as per standard stroke rehabilitation guideline.

Follow-up data as per outcome criteria was collected at the end of 6 months. Standard of care was given to all enrolled patients as per international guidelines.

Outcome Measures: Primary outcome was defined as change in MoCA by 2 points in either direction, or FAB scale by 2 points. While secondary outcomes were MRS; CDPSS, CBS, and P300 values.

Statistical Analysis: Data analysis was done using Statistics Package for Social Sciences (SPSS) version 16. Microsoft Word and Excel were used to generate tables and figures. As per our protocol, only those patients who completed at least 4 weeks of intervention will be finally included in analysis. Tests of normality were done using Shapiro–Wilk test. Mean and standard deviation were used for parametric data, whereas median (interquartile range) was used for nonparametric data. Unpaired t-test, Mann–Whitney U-test (intergroup comparisons), and Wilcoxon signed rank test (intragroup comparisons) were used to compare the baseline and follow-up variables between the cases and controls. A value of $P < 0.05$ was considered statistically significant for all tests.

Table 1A: Comparison of baseline characters of the two groups

Patient Particulars	Yoga group (*n*=40)	Control group (*n*=40)
Mean age	52.85±13.70	55.18±13.24
Male	28 (70%)	31 (66%)
Female	12 (30%)	13 (32.5%)
Educated	30 (75%)	26 (65%)
Uneducated	10 (25%)	14 (35%)
Clinical findings:		
Motor impairment	31 (77.5%)	27 (67.5%)
Aphasia	10 (25%)	9 (22.5%)
Sensory impairment	2 (5%)	6 (15%)
Forced gaze deviation	0 (0%)	0 (0%)
Hemianopia	0 (0%)	1 (2.5%)
Ataxia	8 (20%)	9 (22.5%)
Apraxia	0 (0%)	1 (2.5%)
Others (dysphagia/dysarthria/ vertigo/dizziness/headache)	19 (47.5%)	26 (65%)
Risk factors		
Hypertension	32 (80%)	35 (87.5%)
Diabetes mellitus	15 (37.5%)	16 (40%)
Advanced age (≥60 years)	15 (37.5%)	15 (37.5%)
Smoker	11 (27.5%)	10 (25%)
Chronic kidney disease (CKD)	4 (10%)	2 (5%)
Hereditary/Acquired thrombophilia	0 (0%)	0 (0%)
Coronary artery disease (CAD)	1 (2.5%)	2 (5%)
Family history	6 (15%)	3 (7.5%)
Past TIA/stroke	5 (12.5%)	7 (17.5%)
Body mass index		
Underweight (BMI <18.5)	1 (2.5%)	0 (0%)
Normal BMI 18.5-24.9)	16 (40%)	22 (55%)
Overweight (BMI 25-29.9)	22 (55%)	15 (37.5%)
Obese (BMI ≥30)	1 (2.5%)	3 (7.5%)

Data presented as *n* (%) and mean±SD; *P*<0.05 is significant "*". *P* value for mean age -0.563 (Unpaired *t*-test)

Results

We included 88 individuals presenting with stroke between March 2020 and April 2021. Of these, 8 patients left the proposed intervention within 1 week, and finally 80 patients were included in this study. Thirty patients out of 40 in yoga arm (cases) were compliant and completed the intervention. Two patients withdrew consent after the first 2 weeks of intervention as they complained of generalized body-ache. Six were non-compliant and did not do the intervention in prescribed manner and cited low motivation as the reason for non-compliance, while rest two patients were lost to follow-up. There was no death in the yoga arm. In the control arm, seven patients were lost to follow-up and one patient died during the study period due to myocardial infarction. All other patients were compliant to the standard of care. Demographic details were as given in Table 1A and 1B. Hypertension, diabetes mellitus, and advanced age (≥60 years) were the most common risk factors in both the groups. More than 65% patients in either group presented with motor impairment, 10 (25%) patients in yoga group and 9 (22.5%) in control group had aphasia, followed by ataxia in 8 (20%) patients in yoga group and 9 (22.5%) in control group. There was no significant association between right vs. left hemisphere strokes in the two groups at baseline (p = 0.067). Routine investigations done at

Table 1B: Baseline comparison of radiological characteristics of the two groups

Radiological Findings	Yoga group (*n*=40)	Control group (*n*=40)
Infarct location		
Right hemisphere	13 (32.5%)	22 (55%)
Left hemisphere	20 (50%)	14 (35%)
Bilateral hemispheres	2 (5%)	0 (0%)
Brainstem	5 (12.5%)	4 (10%)
Vascular territory		
ICA	1 (2.5%)	1 (2.5%)
ACA	2 (5%)	0 (0%)
MCA	28 (70%)	30 (75%)
PCA	4 (10%)	3 (7.5%)
VB	7 (17.5%)	7 (17.5%)
Watershed infarcts	1 (2.5%)	0 (0%)
Multi-territorial infarcts	2 (5%) (both PCA & VB)	1 (2.5%) (MCA & PCA)
TOAST Classification		
Large artery atherosclerosis (LAA)	6 (15%)	3 (7.5%)
Cardioembolic stroke (CES)	0 (0%)	1 (2.5%)
Small vessel disease (SVD)	24 (60%)	19 (47.5%)
Stroke of some other determined etiology	1 (2.5%)	1 (2.5%)

Data presented as *n* (%); ICA- internal carotid artery; ACA- anterior cerebral artery; MCA- middle cerebral artery; PCA- posterior cerebral artery, VB- vertebrobasilar baseline yielded comparable results in both the groups. Small vessel disease was the most common mechanism of stroke in both groups [Table 1B].

Baseline median total MoCA and total FAB scores were comparable in both groups (p = 0.075 and P = 0.066, respectively). However, individual domain scores of naming and visuospatial domains in MoCA, and mental flexibility and programming domain scores of FAB were significantly different at baseline [Table 1C]. Baseline CDPSS, MRS, P300 latency, and amplitude were comparable in both groups.

Patients in yoga arm showed significant improvement in total MoCA scores, total FAB scores, MRS, CDPSS, and CBS scores (p = 0.0001) from their baseline scores [Figure 2] [Table 2]. Regarding individual domains of MoCA, significant improvements were seen in visuospatial, attention, abstraction, recall, and orientation. While in FAB subdomains, all, except environmental autonomy, showed significant improvement. Median P300 latencies also improved at Fz, Cz, and Pz at follow-up. However, the changes in P300 amplitudes could not reach a level of significance [Table 2].

In control group, also significant improvements were observed in all the measured scores, i.e., MoCA, FAB, MRS, CDPSS, and CBS (p < 0.0001) [Figure 2]. Improvement was observed in all the domains of MoCA except naming and language. FAB scores improved in all domains. P300 latencies improved at Fz, Cz as well as Pz while amplitude improvement was seen at Fz and Cz amplitude (p < 0.05) [Table 3].

Comparison of cases and controls after 6 months of designated intervention revealed better MoCA scores (25.5, IQR 22-27) and FAB scores (15.5, IQR 14-17) in yoga group compared to that of control group (24, IQR 20-25.75) and (14, IQR 12-15.75) [Figure 2]. The CDPSS score was better in yoga group after intervention (p = 0.0008). However, difference in improvement in the MRS and CBS scores was not statistically significant. P300 latencies improved in both yoga and control group; however, no difference was seen in follow-up P300 latencies values when compared between the two groups. However, the difference in the median amplitudes at Fz, Cz, and Pz was significantly better in control group having higher amplitude [Table 4].

Discussion

Stroke is one of the leading causes of disability, with a sexual dimorphic presentation having male preponderance. More than 65% of our patients were male, of middle age with mean age of 54.01 ± 13.43 years. In present study, we evaluated a spectrum of post-stroke cognitive impairment

Table 1C: Baseline comparison of cognitive functions (using MoCA, FAB), CDPSS, and caregiver burden among yoga and control group

TOOL/SCALE	Yoga group (n=40)	Control group (n=40)	Mann-Whitney U	P
Baseline MOCA	20 (17-22.25)	19 (15.75-21)	615.5	0.075
Visuospatial	2.5 (1-3)	1 (1-3)	577.5	0.024*
Naming	2 (2-3)	2 (2-2)	608.5	0.024*
Attention	4 (2-5)	3.5 (2-4)	720.50	0.431
Language	2 (2-3)	2 (2-2)	672	0.120
Abstraction	1 (0-1)	1 (0-1)	763	0.691
Recall	3 (2-4)	3 (2.75-4)	793.5	0.946
Orientation	5 (4-6)	4.5 (4-6)	702.5	0.318
Baseline FAB	12 (10-14)	11 (8.75-11)	611	0.066
Conceptualization	1 (1-2)	1.5 (1-2)	752.5	0.619
Mental flexibility	2 (1-2)	1 (1-1.25)	528	0.003*
Programming	2 (2-3)	2 (1-2)	564	0.014*
Sensitivity to interference	2 (1-2.25)	2 (1-2)	753.5	0.632
Inhibitory control	2 (1-2)	2 (1-2)	751	0.613
Environmental autonomy	3 (3-3)	3 (3-3)	800	1.0
Baseline CDPSS	1.5 (1-2.25)	2 (1-3)	663	0.172
Baseline CBS	14.5 (8-22.25)	18 (12.75-20)	674.5	0.227
MRS	2 (1-2)	2 (1-3)	655	0.134
P300 values	**Cases (n=37)**	**Controls (n=35)**	**Mann-Whitney U**	**P**
Fz Latency (ms)	414 (323.25-504.75)	410 (370-481.5)	792	0.939
Cz Latency (ms)	418 (342.25-522)	413 (368.75-471.5)	789	0.916
Pz Latency (ms)	429 (348-514)	415 (369-476)	796	0.969
Fz Amplitude (µv)	2.13 (0.71-4.26)	1.83 (0.84-2.51)	705.5	0.363
Cz Amplitude (µv)	2.09 (0.61-4.19)	1.98 (0.97-3.68)	795.5	0.965
Pz Amplitude (µv)	1.76 (0.72-4.80)	2.05 (1.19-4.04)	766	0.743

Data presented as median (IQR); P<0.05 is significant "*". Mann-Whitney U-test. MoCA- Montreal Cognitive Assessment, FAB- Frontal Assessment Battery, CDPSS- Clinician-Rated Dimensions of Psychosis Symptom Severity, and CBS-Caregiver Burden Scale

Table 2: Intragroup comparison of cognitive functions (using MoCA, FAB), CDPSS, and caregiver burden among the yoga group

Tool/Scale	At baseline (n=30)	At follow-up (n=30)	Wilcoxon signed rank z score	*P*
MOCA	20.5 (18-22.25)	25.5 (22-27)	-4.8	0.0001*
Visuospatial	3 (1-3)	3 (3-4)	-3.002	0.003*
Naming	2 (2-3)	3 (2-3)	-1.342	0.180
Attention	4 (2-5)	5 (3.75-6)	-3.89	0.0001*
Language	2 (2-3)	2 (2-3)	-1.6	0.102
Abstraction	1 (0-1)	1 (1-2)	-3.08	0.002*
Recall	3 (3-4)	4 (4-5)	-4.191	0.0001*
Orientation	5.5 (4-6)	6 (6-6)	-3.391	0.001*
FAB	12 (10.75-14)	15.5 (14-17)	-4.81	0.0001*
Conceptualization	1 (1-2)	2 (2-3)	-3.94	0.0001*
Mental flexibility	2 (1-2)	2 (2-2)	-2.95	0.003*
Programming	2 (2-3)	3 (2.75-3)	-3.62	0.0001*
Interference	2 (1-2.25)	3 (2-3)	-3.54	0.0001*
Inhibitory control	2 (1-3)	3 (2-3)	-3.72	0.0001*
Environmental autonomy	3 (3-3)	3 (3-3)	0.0	1.000
CDPSS	1 (1-2)	0 (0-0)	-4.66	0.0001*
CBS	14 (7.75-21.25)	3 (1-6)	-4.70	0.0001*
MRS	1 (1-2)	0 (0-1)	-4.86	0.0001*
P300 values	**At baseline (n=28)**	**At follow-up (n=28)**	**Wilcoxon Signed rank z score**	***P***
Fz LATENCY	419.5 (329.5-548.25)	314.5 (299.25-345.5)	-4.55	0.0001*
Cz LATENCY	416.5 (328-554)	312 (299.5-354.25)	-4.361	0.0001*
Pz LATENCY	415.5 (348-515.5)	312 (299.5-356.75)	-4.493	0.0001*
Fz AMPLITUDE	2.06 (0.68-4.18)	2.30 (1.34-4.12)	-0.091	0.927
Cz AMPLITUDE	2.16 (0.60-5.33)	2.53 (2.03-3.46)	-0.182	0.855
Pz AMPLITUDE	1.70 (0.67-5.26)	1.76 (0.97-4.07)	-0.205	0.838

Data presented as median (IQR); $P<0.05$ is significant "*". Wilcoxon signed rank test. MoCA- Montreal Cognitive Assessment, FAB- Frontal Assessment Battery, CDPSS- Clinician-Rated Dimensions of Psychosis Symptom Severity, and CBS-Caregiver Burden Scale

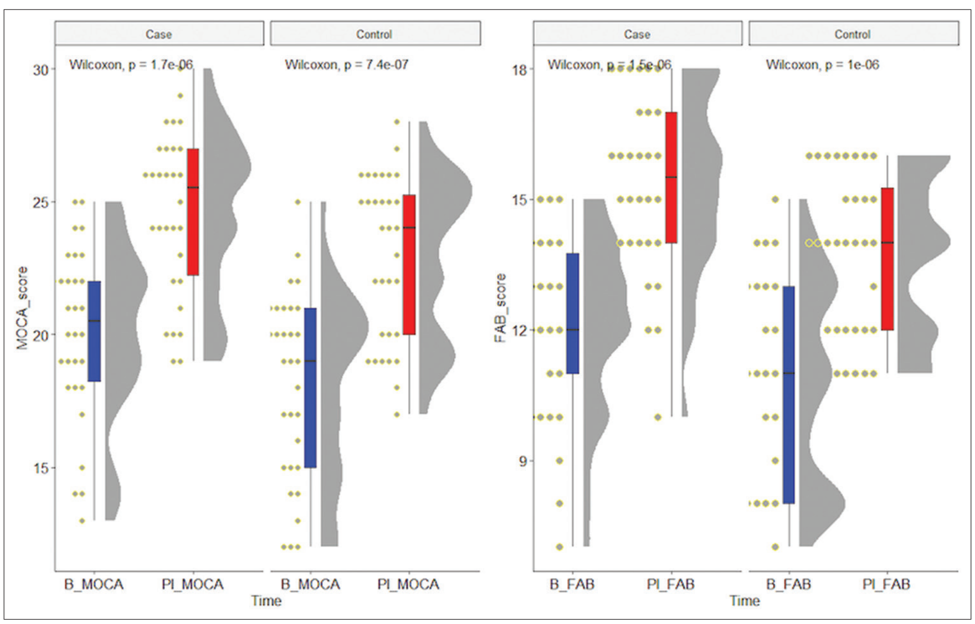

Figure 2: Rain Cloud diagram for cases and controls showing changes in MoCA and FAB scores. Individual points show individual patients, the bifurcating line between the box plot shows median, the maximum distribution of cloud (grey) is showing the maximum clustering of patients at that level

deficits in multiple domains, namely visuospatial, language, naming, programming, conceptualization, mental flexibility, sensitivity to interference, and inhibitory control. Patients of both yoga arm and the control arm showed significant improvements in MOCA and FAB scores after 6 months of follow-up [Figure 2], but these scores were better in yoga

Table 3: Intragroup comparison of cognitive functions (using MoCA, FAB), CDPSS, and caregiver burden among the control group

Tool/scale	At baseline (*n*=32)	At follow-up (*n*=32)	Wilcoxon signed rank z score	*P*
MOCA	19 (15-21)	24 (20-25.75)	-4.96	0.0001*
Visuospatial	1 (1-3)	2 (2-3)	-3.37	0.001*
Naming	2 (2-2)	2 (2-3)	-1.73	0.083
Attention	4 (2-4)	5 (4-6)	-4.32	0.0001*
Language	2 (2-2)	2 (2-2)	-1.0	0.317
Abstraction	1 (0-1)	1 (1-2)	-4.11	0.0001*
Recall	3 (2-4)	4 (3-4)	-3.55	0.0001*
Orientation	4.5 (4-6)	6 (6-6)	-4.04	0.0001*
FAB	11 (8-13)	14 (12-15.75)	-4.89	0.0001*
Conceptualization	1 (1-2)	2 (2-3)	-4.38	0.0001*
Mental flexibility	1 (1-1.75)	2 (2-2)	-4.37	0.0001*
Programming	2 (1-2)	2 (2-3)	-3.50	0.0001*
Interference	2 (1-2)	2 (2-2)	-2.13	0.033*
Inhibitory control	2 (1-2)	2 (2-3)	-2.82	0.005*
Environmental autonomy	3 (3-3)	3 (3-3)	0.0	1.000
CDPSS	2 (1-3)	0 (0-1)	-4.72	0.0001*
CBS	17 (12-20)	6 (2-9.75)	-4.78	0.0001*
MRS	2 (1-2.75)	1 (0-1)	-4.99	0.0001*
P300 values	**At baseline (*n*=29)**	**At follow-up (*n*=29)**	**Wilcoxon signed rank z score**	***P***
Fz LATENCY	410 (373-477)	334 (307-362.5)	-4.60	0.0001*
Cz LATENCY	414 (370-471)	326 (310-364)	-4.59	0.0001*
Pz LATENCY	416 (370-474)	326 (310-359.5)	-4.53	0.0001*
Fz AMPLITUDE	1.94 (0.87-2.83)	3.15 (2.17-4.42)	-3.27	0.001*
Cz AMPLITUDE	1.98 (0.97-3.80)	4.11 (2.37-4.72)	-2.49	0.013*
Pz AMPLITUDE	2.12 (1.19-4.00)	3.59 (2.32-4.16)	-1.91	0.056

Data presented as median (IQR); $P<0.05$ is significant "*". Wilcoxon signed rank test. MoCA- Montreal Cognitive Assessment, FAB- Frontal Assessment Battery, CDPSS- Clinician-Rated Dimensions of Psychosis Symptom Severity, and CBS-Caregiver Burden Scale

arm compared to controls ($p = 0.034$; $P = 0.003$) [Table 4]. In other words, greater number of individuals achieved better scores for both MOCA and FAB in yoga arm, as depicted in the rain cloud diagram [Figure 2]. Almost all the domains of MOCA (except naming and language) and FAB had improvement after 6 months but on intergroup analysis; this difference was significant for the visuospatial, naming, and recall domains of MOCA and for motor programming, sensitivity to interference, and inhibitory control domain of FAB scores ($p < 0.05$) with yoga arm [Tables 2, 3, 4]. Yoga is a simple, economical, and easily acceptable community-based technique which has shown promising results as a neurorehabilitation technique in several diseases including stroke.[6] Schmid *et al*.[7] have shown the beneficial effects of yoga on the multiple aspects of physical functioning. Being effective for psychological wellbeing in addition to the known physical benefits makes yoga fit as an additional neuro-rehabilitative technique among patients of stroke. Huber *et al*.[8] in their meta-analysis tried to explore the effects of motor-cognitive interventions on stroke patients and concluded that beneficial effects of such interventions on the cognitive functions in these patients remain under explored. As post-stroke cognitive and gait impairments have been suggested to share structural and functional roots, stroke has been linked to Motoric Cognitive Risk syndrome, where cognitive and gait impairments remain intertwined.[9] Yoga has shown to improve multiple variables in various population of neurological disabilities including stroke. Hence, in the present study we tried to explore beneficial effects of yoga on cognition in stroke patients, and we found improvement in almost all domains; however, as the median scores in visuospatial and naming of MOCA and motor programming of FAB domain were not comparable at baseline, probably due to differential hemisphere (right vs. left) involvement in the two groups, effect of yoga on these domains remains uncertain. Also, it is noteworthy that for MOCA, we had already added correction factor (1 point) for subjects with total duration of formal education 12 years or less, as per the recommendation.[10] Hence, education is not a confounding factor in our study.

Secondary outcomes were also achieved in both groups showing significant improvement in caregiver's burden score, CDPSS score, and MRS scores The improvement in CDPSS score was significantly better in the yoga arm compared to control arm ($p = 0.0008$). There was no difference in improvement in MRS score between the two groups. This is probably because MRS score is based on functional status, and there is plenty of existing evidence that any kind of physical activity, be it yoga or physical therapy, reduces post-stroke physical disability and improves function.

Table 4: Comparison of cognitive functions (using MoCA, FAB), CDPSS, and caregiver burden among cases and control at 6-month follow-up

Tools/Scales	CASES (*n*=30) Median (IQR)	CONTROLS (*n*=32) Median (IQR)	Mann-Whitney *U*	*P*#
MOCA	25.5 (22-27)	24 (20-25.75)	331.0	0.034*
Visuospatial	3 (3-4)	3 (1.25-3)	337.5	0.031*
Naming	3 (2-3)	2 (2-3)	352.0	0.036*
Attention	5 (3.75-6)	5 (4-6)	444.0	0.598
Language	2 (2-3)	2 (2-2)	400.0	0.146
Abstraction	1 (1-2)	1 (1-2)	473.5	0.917
Recall	4 (4-5)	4 (3-4)	335.0	0.026*
Orientation	6 (6-6)	6 (6-6)	476.0	0.923
FAB	15.5 (14-17)	14 (12-15.75)	275.0	0.003*
Conceptualization	2 (2-3)	2 (2-3)	479.0	0.987
Mental flexibility	2 (2-2)	2 (2-2)	379.0	0.056
Programming	3 (3-3)	2 (2-3)	311.5	0.006*
Interference	3 (2-3)	2 (2-2)	284.0	0.002*
Inhibitory control	3 (2-3)	2 (2-3)	301.5	0.005*
Environmental autonomy	3 (3-3)	3 (3-3)	480.0	1.000
CDPSS	0 (0-0)	0 (0-1)	326.0	0.008*
CBS	3 (1-6)	6 (2-9.75)	405.5	0.289
MRS	0 (0-1)	1 (0-1)	379.0	0.120
P300 values	**Cases (n=28)**	**Controls (n=29)**	**Mann-Whitney U**	***P***
Fz Latency	314.5 (299.25-345.5)	334 (307-362.5)	328.0	0.213
Cz Latency	312 (299.5-354.25)	326 (310-364)	308.5	0.119
Pz Latency	312 (299.5-356.75)	326 (310-359.5)	316.5	0.153
Fz Amplitude	2.3 (1.34-4.12)	3.15 (2.17-4.42)	279.5	0.043*
Cz Amplitude	2.53 (2.03-3.46)	4.11 (2.37-4.72)	268.0	0.028*
Pz Amplitude	1.76 (0.97-4.07)	3.59 (2.32-4.16)	252	0.014*

Data presented as *n* (%) and mean±SD; #Mann-Whitney *U*-test, "*" *P* value <0.05. MoCA- Montreal Cognitive Assessment, FAB- Frontal Assessment Battery, CDPSS- Clinician-Rated Dimensions of Psychosis Symptom Severity, and CBS-Caregiver Burden Scale

Also, reduction in caregiver burden in yoga arm was not significantly greater than that in the control group. This could be because the caregivers mostly focused on the burden due to physical impairment which showed improvement with early intervention of yoga or physical exercise in either of the groups. Additionally, the patients enrolled in our study only had mild-to-moderate disability. Hence, the burden was probably not as significant as it would have been with severe physical disability.

Dejanović *et al*.[11] demonstrated that P300 latencies in stroke patients were significantly longer and the P300 amplitudes were significantly smaller than those of the control group. Both these changes are indicators of cognitive slowing and have been observed in various diseases and brain injury.[11] In their study, the latency of P300, but not the amplitude, showed a highly significant average improvement 12 months after the stroke compared to that at baseline without any intervention. Similar improvement was also seen in our study in the P300 latencies in both the groups after 6 months of follow-up; however, no differences were observed in the P300 latencies between cases and controls neither at baseline nor at follow-up. Interestingly, there was significant improvement in the amplitude of P300 in control arm at Fz, Cz, and Pz but no improvement in yoga arm. Although P300 is used as a correlate in cognitive processing, there is still ambiguity regarding the neural generators of P300. P300 amplitude increases with an increase in mental effort, but a decline in P300 amplitude with increasing task difficulty has also been reported.[12,13] Probably, recruitment of few compensatory additional neural networks affects the P300 amplitudes.[14] Intracranial studies, lesion studies, and fMRI-EEG studies point toward multiple neural generators of P300. Hence, P300, recorded at different places, may have different source resulting from different mixture of cognitive mixtures. In another words, the P300 measured at Fz consists of another source mix (i.e., reflecting a different mixture of cognitive processes) than the P300 at Pz, and if this source mix changes, differences in trajectories are to be expected.[15] Hence, it may be possible that compensatory recruitment of neural circuits with the help of yoga differs from those recruited after spontaneous recovery and may be responsible for the difference in the amplitude.

In a study of moderate stroke patients, 58 patients were divided into yoga and conventional treatment groups.[16] After 12 weeks of yoga training, the cerebral blood oxygen content of stroke patients had significantly increased, and blood oxygen contents gradually approached that of normal people. On weekly monitoring, it was found that significant increase in blood oxygen content in brain of patients started in the third week of experiment. Furthermore, in this study, the recovery of cognitive function was inspected by monitoring the brain wave of patients when faced with a problem.[16] The authors reported that, with the same problem, yoga-trained patients showed greater brain activity compared to those who underwent conventional rehabilitation therapy. Moreover, the significant difference in the brain waves between experimental and control group basically appeared in the fourth and fifth week of experiment. This study showed that the yoga increases blood oxygen content and probably enhances the brain activity and improves cognitive ability.[16] In another systematic review, it has been suggested that healthy yoga practitioners have higher GM volume in a number of regions involved in cognitive function including frontal lobe (i.e., bilateral orbital frontal, right middle frontal, and left precentral gyri), limbic (i.e., left parahippocampal gyrus, hippocampus, and insula), temporal (i.e., left superior temporal gyrus), occipital (i.e., right lingual gyrus), and cerebellar regions.[17] Another important aspect of cognition specially for memory is the default mode network (DMN) of the brain. It is usually activated during rest and deactivated with an external task. Usually, connectivity of DMN decreases with age and in dementia. This review also reported a better DMN activity with yoga practice. Hence, we can hypothesize that yoga might have changed the various connectivity and gray matter densities in patients with PSCI, resulting better outcome.

Although studies have explored the effects of yoga on improvement in post-stroke motor function and balance, data on its effects on post-stroke cognitive impairment is scarce. Our study is probably first randomized controlled study which has explored this aspect. The yoga exercises prescribed in our study were suitable for rehabilitation of stroke patients with moderate disability (MRS 3 or below). Our study is also unique as it focuses on early yoga intervention. Hence, our study shows that early yoga intervention in stroke survivors will improve their cognitive abilities. Our study used tele-yoga, which had many advantages. It provided easy access to patients, especially during the pandemic when movement was restricted across the country. It also saved transport costs for patients and increased compliance. In our study, the compliance was 75%. Most common reason for non-adherence was feeling of fatigue and generalized weakness and low motivation. There were no deaths in the yoga arm during the period of study, while 1 death was reported in the control arm due to myocardial infarction. The limitation of our study was its small sample size. This study can serve as the stepping stone to future large-scale, well-designed trials in this regard.

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Conflicts of interest

There are no conflicts of interest.

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