ORIGINAL ARTICLE

Randomized clinical trial of yoga-based intervention in residents from elderly homes: Effects on cognitive function

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ABSTRACT

Context: Elderly have increased risk for cognitive impairment and dementia. Yoga therapy may be helpful in elderly to improve cognitive function.

Aims: We examined the benefits of yoga-based intervention compared with waitlist control group on cognitive function in the residents of elderly homes.

Settings and Design: Single blind controlled study with block randomization of elderly homes.

Materials and Methods: Study sample included yoga group (n=62) and waitlist group (n=58). A total of 87 subjects (yoga=44, waitlist=43) completed the study period of 6 months. Yoga group received daily yoga sessions for 1 month, weekly until 3rd month and encouraged to continue unsupervised until 6 months. They were assessed on Rey's Auditory Verbal Learning Test (RAVLT), Rey's complex figure test (CFT), Wechsler's Memory Scale (WMS)-digit and spatial span, Controlled Oral Word Association (COWA) test, Stroop Color Word Interference Test and Trail Making Test A and B at baseline and at the end of 6th month.

Statistical Analysis: Paired t-test and analysis of covariance (ANCOVA) to compare the difference in neuropsychological test scores.

Results: Yoga group showed significant improvement in immediate and delayed recall of verbal (RAVLT) and visual memory (CFT), attention and working memory (WMS-spatial span), verbal fluency (COWA), executive function (Stroop interference) and processing speed (Trail Making Test-A) than waitlist group at the end of 6 months after correcting for corresponding baseline score and education.

Conclusion: Yoga based-intervention appears beneficial to improve several domains of cognitive function in elderly living in residential care homes. Study findings need to be interpreted after considering methodological limitations like lack of active comparison group.

Key words: Cognitive function, elderly, yoga

INTRODUCTION

India's elderly population in the age group of 60 years and above has increased significantly and is projected to further increase rapidly than many other developed countries in the future. Dementia in elderly is emerging as a major public health problem due to increase in prevalence and lack of effective disease modifying treatment.[1] Cognitive stimulation and physical activity has a role in promoting cognitive function, preventing cognitive decline and

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dementia in elderly.[2] Epidemiological observational studies have shown lesser risk for cognitive decline and dementia in elderly with regular physical activity and cognitive stimulation.[3-5] Similarly, controlled trials have shown better cognitive function in elderly undergoing interventions to promote cognitive stimulation and physical activity.

In a meta-analysis of 18 intervention studies of aerobic fitness training performed between 1966 and 2001, there was a moderate effect size (0.48) for positive role of physical activity on cognitive function in elderly.[6] Similarly, recent studies by Lam *et al*. on Tai Chi,[7] Maki *et al*. on the walking program,[8] Moro *et al*.[9] and Cheng *et al*.[10] on cognitive stimulation, Lautenschlager *et al*.[11] on walking and other forms of physical activity and Baker *et al*.[12] on aerobic exercise have shown improvement in cognitive function in the intervention group than the control group. A recent study by Cheng *et al*. has shown benefits of cognitive stimulation (Mahjong) and physical activity (Tai Chi) in subjects with early dementia by delaying cognitive decline.[13]

However a recent National Institute of Health consensus statement on this topic has concluded that there is limited and inconclusive evidence for the protective role of cognitive stimulation and physical activity in preventing cognitive decline and dementia.[14] They emphasized the need for more studies in this area to strengthen the evidence.

Yoga, with its roots in ancient Indian philosophy, is used for physical, mental and spiritual well-being. Yoga as therapy uses physical postures (āsanas), breathing exercises (Prāṇāyāma) and meditation techniques. Independently and/or comprehensively these have been shown to improve several cognitive functions such as executive functions, attention, intelligence, memory and concentration.[15-19]

There are very limited studies, which have focused on the effects of yogic practices on cognitive function in elderly. Current study is aimed at testing the effects of yoga-based intervention on memory and other cognitive functions in residents of elderly homes.

MATERIALS AND METHODS

Settings and design

This was a randomized controlled study approved by the Institutional Ethical Committee of the National Institute of Mental Health and Neurosciences. Subjects were recruited from nine consenting elderly homes in and around Bangalore city, India. Lectures were organized in these elderly homes to convey the details of the study. Interested candidates were then subjected to screening for inclusion in the trial. Subjects were recruited after they signed written informed consent form providing adequate information about the nature of the study. Each old-age home as a block was randomized to either yoga or waitlist group by generating a random number table for allocation of each group by an independent researcher who was not involved in the study assessments.

Participants

All eligible elderly aged above 60 years were recruited from these consenting elderly homes. Subjects with dementia or other neurodegenerative disorder, stroke, major depressive disorder, psychosis, anxiety disorder, severe hearing and visual impairment and inability to perform yogic practices were excluded from the study.

Instruments used

Detailed information about the socio-demographic variables as well as subject's status of chronic medical illness, current medication, level of physical activity and physical fitness were recorded.

Screening instruments

Subjects were screened with Geriatric Depression Scale-15 (GDS-15)[20] Hindi Mental State Examination (HMSE)[21] an Indian adaptation of Mini Mental State Examination and Mini-International Neuropsychiatric Interview[22] for excluding dementia, depression and other psychiatric disorders. Subjects were also evaluated by a clinician with training in psychiatry to rule out the presence of depression, dementia and other psychiatric disorders. Subjects with a GDS score of more than 4 and HMSE score less than 26 out of maximum 31 were excluded from the current study.

Neuropsychological battery

Neuropsychological tests were administered by trained researchers in the elderly home. The tests were administered usually in a single sitting of 60-90 min duration. Subjects were given a break for few minutes if required. Assessment of verbal, visual and working memory were carried out with Rey's Auditory Verbal Learning Test (RAVLT),[23] Rey's complex figure test (CFT)[24] and Wechsler Memory Scale (WMS)-digit and spatial span[25] respectively. Controlled Oral Word Association (COWA) test,[26] Stroop color word interference test[27] and Trail Making Test A and B[28] were used to test the verbal fluency, attention and executive function part of the cognition. These are standard neuropsychological tests used widely in many studies. We had used the Indian adaptation of these tests.[26]

COWA measuring phonemic fluency included generation of words starting with consonants "Ka," "Pa" and "Ma" within 1 min for each sound. Average number of words generated for three sounds was taken as a composite score for analysis. RAVLT included 5 learning trials with 15 word list A followed by 1 trial with list B containing different set of 15 words. Subsequently the immediate and 20 min delayed recall of words from list A was assessed. During the intervening period, other neuropsychological assessments were carried

out. Rey's CFT included reproduction of a complex line drawing, initially by copying and later from memory after a gap of 3 min and 30 min. WMS digit span test included verbal repetition of the series of digits in forward and backward order. WMS spatial span test is a visual analogue of digit span test, which included tapping of prearranged blocks in forward and backward sequence. Stroop test included measurement of time taken in seconds to read words spelling out colors printed in black ink (word), naming the printed colors (color) and naming the ink color while the printed name is a different color than the ink color (interference). Trail Making Test-A (TMT-A) included measurement of time taken in seconds to connect number (digits) in ascending series of circles arranged randomly on paper as fast as possible. TMT-B included measurement of time taken in seconds to connect number (digits) and letters (alphabets) in alternating order.

After the baseline assessments, subjects who were randomized to yoga group received the yoga-based intervention (see below for details). Whereas waitlist control group did not receive any intervention during the study period. However, subjects in the waitlist period were assured of yoga intervention at the end of 6 months if they wished. All the assessments were repeated after 6 months.

Yoga intervention

The yoga program for improving cognition and quality of life in elderly was developed by reviewing traditional and contemporary yogic texts. This yoga package was sent for validation to ten experts in the field of yoga and integrative medicine for its appropriateness in elderly. Thus, validated yoga program consisted of Yogāsana, (loosening exercises), Sukṣmavyayāma (physical postures), Prāṇāyāma, (breathing exercises) and meditation in the form of Nādānusandhāna (OM meditation). The detail of the validation of this yoga module is discussed in another paper separately.[29] The component of the yoga module is shown in Table 1. Subjects in the yoga group received 60 min yoga-based intervention by a trained yoga therapist daily for the 1 month (except on holidays). In the next 2 months, the yoga therapist conducted weekly sessions each of 1 hour. After this, they were encouraged to practice yoga on their own for the next 3 months.

The subjects' ability to perform yoga was assessed by the yoga instructor at the end of 1 month, 3rd month and 6th month. Subjects were asked to keep a log on performance of the yoga session during the last 3 months. However, many of the participants failed to keep these logs consistently. But most of the participants reported that they were engaging in yoga at least 3-4 times/week during these follow-up months. Same yoga therapist instructed and monitored the sessions for all the subjects in the study. Subjects in the waitlist control group did not receive any intervention during the study period.

Table 1: Yoga module components

Procedure	Duration
Sūkṣma vyāyāma (Loosening exercises) Kaṇṭa grīvā sancalana (Neck Exercises), Skandha sancalana (Shoulder Exercises) Kaṭi sancalana (Hip exercises), Jānu sancalana (Knee Exercises) Pāda sancalana (Ankle & Feet Exercises)	10 Minutes
Yogāsana Tādāsana, Kaṭi-cakrāsana, Koṇāsana, Mārjāri asana, Vakrāsana, Viparītakaraṇi Bhujangāsana, Ardha śalabhāsana, Pavanamuktāsana, Setubhandhāsana, śavāsana	20 Minutes
Prāṇāyāma Kapālabhāti, Nādiśuddhi, Sūryānuloma-viloma Candrānuloma-viloma, Bhastrikā, Bhrāmari	15 Minutes
Trāṭaka & Meditation Jyoti trāṭaka, Nādānusandhāna (Om meditation)	15 Minutes

At the beginning of the study, before randomization; subjects in both groups were educated about dementia and importance of physical activity including yoga in maintaining cognition. During these 6 months, most of the subjects in both groups were engaged in walking. Most of the subjects were engaged in spiritual activities (Singing, chanting, attending spiritual discourses) in both groups. Other than these, none of the subjects in the waitlist group were engaged in any form of yoga-like physical activity nor did the old age homes have any other structured yoga-like activity offered during the study period.

Statistical analysis

Univariate statistics was used to compare demographic and other characteristics of the two groups. Per protocol analysis with subjects completing the study at the end of 6 months study period was done as the primary outcome analysis. Pre-post difference in scores were analyzed using paired *t*-test. Group differences were tested using analysis of co-variance (education and corresponding baseline measure as covariates). Statistical significance was fixed at $P<0.05$. In addition, in order to include all individuals enrolled in the study (both completers and dropouts) for the analysis, intent-to-treat (ITT) approach was employed by last observation carried forward (LOCF) method for missing data. Statistical analysis was performed using the SPSS version 13.0 for windows (SPSS Inc, 2006).[30]

RESULTS

Out of 120 subjects (yoga=62, waitlist control=58) consented and participated in the study, 87 subjects (yoga=44, control=43) completed the study for whom both baseline and 6th month follow-up assessments were available. Some of the common reasons for drop out were inability to participate in yoga sessions, shift to different elderly homes and/or non-availability for follow-up [Consort Flow Chart-Figure 1]. Baseline variables of the drop out subjects did not significantly differ from those who completed the study (data not shown).

Socio-demographic profiles of yoga and waitlist group were comparable except for education [Table 2]. Yoga group subjects were more educated compared to the waitlist controls (P=0.037).

Majority of the study population (yoga-91.9%, waitlist control-91.4%) had one or more medical illness. Median number of medical illness in both groups was three. Hypertension was the most common medical illness in both the groups (69.4% in yoga group and 60.3% in the control group). There was no significant difference in the number of medical illness or the frequency of individual medical illness between the two groups. The scores on the screening instruments namely GDS and HMSE were not different between the groups.

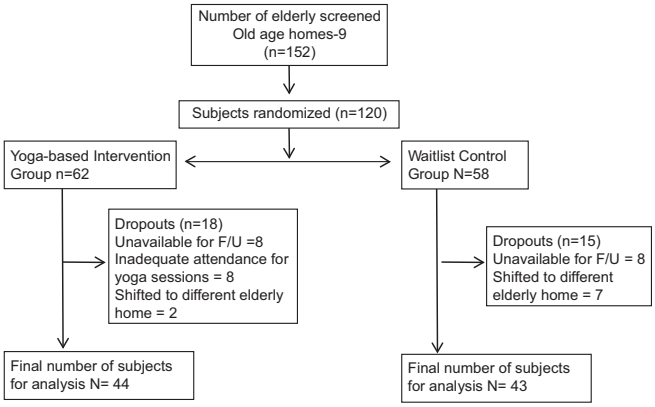

Figure 1: Consort flow chart

Table 2: Socio demographic comparisons between yoga and control groups

Variable	Yoga (n=62)	Waitlist (n=58)	t/x2	*P* value
Age in years	75.74 (6.46)	74.78 (7.35)	0.77	0.445
Education in years	13.05 (4.09)	11.41 (4.38)	2.12	0.037*
Family monthly Income in Rupees/Month#				
1-5000	6 (9.7%)	10 (17.2%)	1.48	0.286
5001 & Above	56 (90.3%)	48 (82.8%)		
Sex# Female	36 (58.1%)	36 (62.1%)	0.20	0.655
Subjective Memory complaints#	50 (80.6%)	40 (69.0%)	2.18	0.140
Number of medical illness	2.77 (1.66)	2.86 (1.71)	0.29	0.776
Geriatric depression scale	2.23 (1.61)	1.79 (1.45)	1.54	0.126
Hindi Mental State Examination	29.05 (1.59)	29.19 (1.26)	-0.54	0.593

*Statistically significant with *P* value <0.05; #Expressed as Number (percentage within group); Other Values expressed as Mean (Standard deviation)

There was a significant difference between the two groups on some of the baseline neuropsychological test scores. RAVLT – immediate recall and Stroop interference scores were better in waitlist group. Yoga-based intervention group performed better than waitlist group in CFT – copying, digit span forward and backward [Table 3].

Outcome variables at 6th month follow-up (per protocol completer analysis)

Paired *t*-test analysis for the changes from baseline to 6th month showed that yoga group improved significantly in (COWA), RAVLT: Total score, immediate recall and delayed recall; CFT: Immediate and delayed recall; spatial span-forward and backward, Stroop interference and TMT-A. The waitlist control group significantly worsened in Stroop interference [Tables 4 and 5].

Group differences for neuropsychological test scores at 6th month follow-up

After covariating the years of education and corresponding baseline score, the yoga group had significantly better scores at the end of 6 months on following variables; RAVLT: Total, immediate recall and delayed recall scores; CFT: Delayed recall; WMS-spatial span-forward, Stroop interference and TMT-A [Tables 4 and 5].

ITT analysis after imputing the missing data by carrying

Table 3: Baseline neuropsychological test scores for all subjects

Variable	Mean (Standard deviation)		t	*P* value
	Yoga(n=62)	Waitlist(n=58)		
COWA	8.55(3.46)	7.69(3.68)	1.33	0.188
RAVLT-Total Score	39.37(10.70)	40.31(8.90)	-0.52	0.603
RAVLT-Average Score	7.84(2.16)	8.06(1.78)	-0.60	0.551
RAVLT-Immediate Recall	7.15(3.10)	8.40(2.10)	-2.57	0.011*
RAVLT-Delayed Recall	7.55(3.10)	7.86(2.47)	-0.60	0.550
CFT-Copy	30.05(5.78)	27.62(6.93)	2.09	0.039*
CFT-3 Minutes	10.32(5.75)	11.44(5.90)	-1.05	0.295
CFT-30 Minutes	9.31(4.78)	9.22(5.48)	0.09	0.930
Spatial Span-Forward	7.03(1.49)	6.55(1.40)	1.81	0.072
Spatial Span-Backward	5.18(1.61)	4.84(1.89)	1.04	0.300
Digit Span-Forward	7.85(1.58)	6.97(1.92)	2.78	0.006*
Digit Span-Backward	5.18(1.51)	4.57(1.50)	2.21	0.029*
Stroop Interference (in seconds)	182.61(68.67)	153.96(52.20)	2.54	0.012*
Stroop Interference (Error)	9.93(9.38)	13.89(13.22)	-1.89	0.062
Trail Making Test-A (in seconds)	86.42(45.18)	94.00(51.67)	-0.86	0.393
Trail Making Test-B (in seconds)	189.23(88.49)	193.10(96.40)	-0.22	0.824

*Statistically significant with *P* value <0.05

Table 4: Baseline to 6th month paired 't' test and between group comparisons of neuropsychological test scores

Variable		Subjects (n=87) Mean (Standard deviation)		Baseline to 6th month change		Between group ANCOVA	
	Group	Baseline	6th Month	t	*P* value	F (df)	*P* value
COWA	Yoga	8.68 (3.73)	9.66 (3.71)	-2.61	0.013*	2.06(1/83)	0.155
	Waitlist	7.88 (3.77)	8.20 (3.78)	-1.07	0.293		
RAVLT-Total	Yoga	38.90 (9.81)	43.93 (10.07)	-4.71	0.000*	5.26 (1/83)	0.024*
	Waitlist	39.77 (8.75)	40.74 (10.28)	-0.87	0.390		
RAVLT-Average	Yoga	7.76 (1.97)	8.78 (2.02)	-4.93	0.000*	5.66 (1/83)	0.020*
	Waitlist	7.95 (1.75)	8.15 (2.06)	-0.87	0.390		
RAVLT-Immediate Recall	Yoga	7.39 (3.07)	8.98 (2.86)	-4.37	0.000*	11.43(1/83)	0.001*
	Waitlist	8.51 (2.13)	7.95 (2.68)	1.18	0.078		
RAVLT-Delayed Recall	Yoga	7.45 (3.08)	9.55 (3.27)	-6.60	0.000*	15.61(1/83)	0.000*
	Waitlist	7.81 (2.58)	7.58 (3.23)	1.10	0.591		
CFT-Copy	Yoga	30.14 (5.73)	29.49 (6.69)	0.77	0.447	0.29 (1/83)	0.591
	Waitlist	26.81 (7.62)	26.07 (8.40)	0.77	0.445		
CFT-3 Minutes	Yoga	10.73 (5.88)	12.58 (5.81)	-2.71	0.010*	3.35 (1/83)	0.071
	Waitlist	11.19 (6.48)	11.05 (6.31)	0.19	0.851		
CFT-30 Minutes	Yoga	9.73 (4.75)	11.85 (5.72)	-3.54	0.001*	5.06 (1/83)	0.027*
	Waitlist	9.14 (5.65)	9.15 (6.25)	-0.02	0.986		

*Statistically significant with *P* value <0.05

Table 5: Baseline to 6th month paired 't' test and between group comparisons of neuropsychological test scores

Variable		Subjects (n=87) Mean (Standard deviation)		Baseline to 6th month change		Between group ANCOVA	
	Group	Baseline	6th Month	t	*P* value	F (df)	*P* value
Spatial Span Forward	Yoga	7.14 (1.50)	7.80 (1.55)	-3.06	0.004	6.44(1/83)	0.013
	Waitlist	6.58 (1.31)	6.77 (1.53)	-0.92	0.365		
Spatial Span Backward	Yoga	5.16 (1.73)	5.68 (1.87)	-2.18	0.035	3.33(1/83)	0.071
	Waitlist	4.56 (1.87)	4.65 (1.86)	-0.36	0.724		
Digit Span-Forward	Yoga	7.80 (1.50)	7.77 (1.31)	0.12	0.903	2.84(1/83)	0.096
	Waitlist	6.98 (1.97)	6.84 (1.66)	0.69	0.492		
Digit Span-Backward	Yoga	5.11 (1.54)	5.30 (1.23)	-0.85	0.400	1.50(1/83)	0.224
	Waitlist	4.44 (1.39)	4.51 (1.70)	-0.36	0.719		
Stroop Interference (in seconds)	Yoga	188.14 (72.14)	167.92 (66.77)	2.32	0.026	4.29(1/81)	0.042
	Waitlist	152.50 (56.21)	175.10 (53.67)	-2.69	0.010		
Stroop Error (in seconds)	Yoga	9.44 (7.68)	11.20 (10.64)	-1.58	0.121	0.10(1/81)	0.757
	Waitlist	13.98 (13.13)	14.24 (10.82)	-0.17	0.866		
TMT-A (in seconds)	Yoga	88.86 (50.01)	79.18 (50.64)	2.51	0.016	4.71(1/83)	0.033
	Waitlist	97.21 (52.50)	109.93 (74.79)	-1.49	0.145		
TMT-B (in seconds)	Yoga	188.02 (94.47)	182.36 (100.44)	0.54	0.590	1.77(1/76)	0.188
	Waitlist	204.21 (106.10)	228.00 (146.86)	-1.29	0.206		

*Statistically significant with *P* value <0.05

forward the last observed value was done to measure the outcome as additional analysis. The results were essentially similar to the findings from completer analysis except the lack of significant improvement in Stroop interference (data not shown).

DISCUSSION

We studied the effects of yoga-based intervention on cognitive function in residents living in elderly homes using a randomized controlled trial. Subjects were 60 years or older without dementia or major depressive disorder. Nearly two third of the subjects had subjective memory complaints. However, there was no statistically significant difference in the proportion of subjects with memory complaints between the two study groups.

The randomization was performed taking each old age home as a block. The yoga and waitlist control groups were not comparable on all parameters in the baseline suggesting that such randomization was not perfect, though the total sample was fairly large. Therefore, the analysis for group differences at 6 months was conducted with years of education and corresponding baseline measure as covariates.

Subjects in the yoga group showed significant improvement from the baseline performance in verbal fluency, immediate and delayed recall of verbal and visual memory, attention, working memory and executive function after the study period of 6 months. However, in the waitlist control group during the corresponding period, there was significant worsening of performance in executive function test assessed

through Stroop interference. There was no significant change in the performance of other cognitive function tests.

Analysis of covariance (ANCOVA) to measure the group difference in the performance of cognitive measures after the 6 months study period showed better performance scores on immediate and delayed recall of verbal memory, delayed recall of visual memory, attention and processing speed in the yoga group. No spontaneous reporting of adverse events occurred in either group.

This suggests a favorable effect of yoga based intervention in elderly on cognitive functions. Several studies have reported positive benefits of exercise/physical activity and cognitive stimulation on cognitive function in elderly. These studies have used different methods of physical activity and cognitive stimulation.[6-13] Yoga based intervention has components of both physical activity and cognitive stimulation. There are very limited studies exploring the effects of yoga therapy on cognitive function in elderly. The findings of our study suggest positive benefits in cognitive function for elderly practicing yoga therapy than waitlist control. A recent study showed better cognitive performance in long-term Vihangam Yoga meditators than age and education matched controls.[31] However, a previous study by Oken *et al*. failed to demonstrate a difference between yoga and exercise as regards to effects on cognition in the elderly.[32] Their subjects were cognitively healthy unlike the majority in our sample reporting subjective memory complaints. Our study subjects may have had some scope to cognitively improve, unlike those in the Oken *et al*. study. Furthermore, the comparison group in this latter study was exercise unlike only waitlist in our study. Further, our design allowed more yoga sessions. Overall, design of our study might be more likely to detect the cognitive effects of yoga in the elderly. The finding encourages using yoga as a life-style for the cognitive benefits in the elderly. In this design, it is difficult to recommend yoga as an alternative to exercise. Biological correlates of this behavioral benefit of yoga deserve attention in future studies. For example, Erickson *et al*. demonstrated that exercise over a period of 1 year increased hippocampal volume, which was associated with greater serum levels of brain-derived neurotrophic factor.[33]

Limitations of the study

The randomization was not entirely perfect. Since the older adult population studied in this study belonged to residential care, generalization of the results to the elderly living with families may be limited. Including an active comparative group like aerobic exercise would have controlled for the effects of other non-specific factors. Measurement of outcome variables at multiple time points would have been more informative as cognitive domains can have differential trajectory of change. Significant drop out rate of more than 25% is an important limitation, particularly with a moderate sample size. The limitations of ITT analysis with imputation of LOCF data have been highlighted.[34] Use of mixed model for longitudinal analysis is suggested as a better alternative for LOCF analysis when the sample size is large and the dropout rate is less than 20%. In this study, we could not use the mixed model analysis as our study sample size was not large and the dropout rate was more than 20%.

Within these limitations, the study findings provide preliminary data to support the beneficial role of yoga-based intervention on memory and other cognitive functions in the elderly. Including yoga as a daily activity in old-age homes can be considered to promote cognitive function in elderly. There is a need for more studies evaluating the role of yoga on cognitive function in elderly with rigorous methodology overcoming the limitations of the current study. In future studies, it will be important to assess whether the improvement in cognitive function measured with neuropsychological tests can translate in to real life functional advantage. Furthermore, long-term follow-up studies are required to evaluate whether yoga intervention will reduce the incidence or progression of cognitive impairment in the elderly to dementia.

CONCLUSION

Yoga based intervention appears to have a beneficial effect on cognitive functions like delayed recall of verbal and visual memory, attention, executive function and psychomotor speed when practiced for 6 months in the elderly. Findings encourage the use of yoga as a life-style practice in the old age homes. However, the study findings need to be interpreted after considering the methodological limitations discussed above. There is a need for future studies with study design overcoming the limitations to get better evidence for the efficacy of yoga in improving the cognitive function in elderly.

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