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Effect of yoga on cognitive functions in climacteric syndrome: a randomised control study

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Objective To assess the efficacy of an integrated approach of yoga therapy (IAYT) on cognitive abilities in climacteric syndrome.

Design A randomised control study wherein the participants were divided into experimental and control groups.

Settings Fourteen centres of Swami Vivekananda Yoga Research Foundation, Bangalore, India.

Sample One hundred and eight perimenopausal women between 40 and 55 years with follicle-stimulating hormone level equal to or greater than 15 miu/ml. One hundred and twenty perimenopausal women were randomly allotted into the yoga and the control groups.

Methods The yoga group practised a module comprising breathing practices, sun salutation and cyclic meditation, whereas the control group practised a set of simple physical exercises, under supervision (1 hour/day, 5 days/week for 8 weeks).

Main outcome measures Assessments were made by vasomotor symptom checklist, six-letter cancellation test (SLCT) for attention and concentration and Punit Govil Intelligence Memory Scale (PGIMS) with ten subtests.

Results The Wilcoxon test showed significant ($P < 0.001$) reduction in hot flushes, night sweats and sleep disturbance in yoga group, with a trend of significant difference between groups at $P = 0.06$ on Mann–Whitney test in night sweats. There was no change within or between groups in the control group. The SLCT score and the PGIMS showed significant improvement in eight of ten subtests in the yoga group and six of ten subtests in the control group. The yoga group performed significantly better ($P < 0.001$) with higher effect sizes in SLCT and seven tests of PGIMS compared with the control group.

Conclusions Integrated approach of yoga therapy can improve hot flushes and night sweats. It also can improve cognitive functions such as remote memory, mental balance, attention and concentration, delayed and immediate recall, verbal retention and recognition tests.

Keywords Climacteric, cognitive abilities, yoga.

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Introduction

Climacteric is a physiologic transition characterised by depletion of the ovarian follicles, decreasing estradiol and inhibin production, leading to an increase in follicle-stimulating hormone (FSH), loss of menstrual cycle, accompanied by menopausal symptoms.[1] Because the average life span of women in India has touched 62 years, the problems of menopause have attained a greater attention.[2] Altered levels of neurotrophic ovarian steroid (17beta-estradiol) have been recognised as one of the factors influencing degenerative processes that lead to ageing.[3] Senescence is characterised neurologically by a decline in cognitive function.[4] Cognitive decline during ageing is seen in memory abilities,[5] focusing, attention[6,7] and information processing.[8] Numerous studies indicate that estrogen is essential for optimal brain function. Estrogens have been reported to influence verbal fluency, verbal memory tests and performance on spatial tasks and fine motor skills.[9–12] This decline is the result of degenerative processes initiated by dysregulation of the hypothalamic–pituitary–gonadal (HPG) axis with menopause and andropause that leads to alterations in the concentration of all serum HPG hormones. Estrogen is known to enhance the activity at neuronal synapses, thus exerting its direct neuroprotective and neurotrophic effects on brain tissue, by maintaining the integrity of the nigral-dopamine system.[13] These dopamine-producing neurons that are involved in cognitive functions start dying when estrogen levels are low.[14] The protective effect

of estrogens on neuronal cells may also be due to their ability to alter free radical production and/or free radical action on cells.[15] It has been shown that estrogen deprivation is likely to initiate or enhance degenerative changes caused by oxidative stress and to reduce the brain's ability to maintain synaptic connectivity and cholinergic integrity leading to the cognitive decline seen in aged individuals.[16]

The hippocampus has long been presumed the primary site of action of estrogens on cognition; and explicit memory is considered the cognitive function most vulnerable to menopausal loss of estrogen. Keenan *et al.* hypothesised that the prefrontal cortex and its neural circuitry are prime mediators of estrogen's role in cognition. The prefrontal cortex is critical for intact working memory, and estrogen enhances performance on working memory tasks.[17] Neuroimaging techniques like positron emission tomography and magnetic resonance imaging proved that estrogen-induced increase in cerebral blood flow were particularly noticed in the hippocampus, para hippocampus, gyrus and temporal regions, which are a part of memory circuit.[18] Murphy *et al.*[19] reported that age-related loss of brain tissue in hippocampus and parietal lobes was significantly greater in women than in men. Thus, estrogen strongly influences mood and cognition, and the decline of this hormone at menopause can produce significant emotional and cognitive problems in women.[9]

No doubt hormone replacement therapy (HRT) reverts the cognitive, vasomotor and psychological impairments and is cardio-protective, but holds a risk of cancer of endometrium and breast, as well as three-fold risk of venous thromboembolism.[20] Due to these serious adverse effects of HRT, there has been a gap in the management of menopausal symptoms emphasising the need to develop and explore the efficacy of alternative therapeutic avenues that have demonstrated promise in alleviating menopausal symptoms since 2006.[21] Cognitive-behavioural intervention was shown to be effective in treating anxiety, depression, hot flushes and cardiac complaints, improving partnership relations and overall score of sexuality in a pilot study on 30 women with climacteric syndrome.[22] There are very few studies on yoga treating used for climacteric syndrome. There are several studies (two pilot studies and one three-armed study) that shows that yoga improves the menopausal symptoms,[23–25] but there are no studies on the effect of yoga on cognitive functions in climacteric.

Yoga is an ancient Indian science and way of life that includes the practice of specific postures, regulated breathing and meditation.[26] *Yogasanas* and *pranayamas* are today recognised as techniques that can improve muscle strength, flexibility, blood circulation and oxygen uptake as well as hormone functions[27] at the gross level. Meditation (intrinsic yoga techniques called *Dharana*, *Dhyana* and *Samadhi*) has been described as training in awareness, produces definite changes in perception, attention and cognition.[28] It has been shown that processing of sensory information at the thalamic level is facilitated during the practice of pranayama (breathing exercises)[29] and meditation.[30] Integrated approach of yoga that combines physical postures, pranayama and meditation together with the notional correction based on philosophy of yoga was found to improve both cognitive (visual perception) and motor functions (hand steadiness)[31] in college students following 10 days of yoga practice. This improvement was believed to be due to improved eye hand coordination, attention, concentration and relaxation. With these promising benefits of yoga, we could hypothesise that yoga may decrease the cognitive dysfunction and the clinical symptoms of climacteric.

Thus, the aim of the study was to assess the efficacy of the integrated approach of yoga therapy (IAYT) on cognitive functions in perimenopausal women.

Methods

Participants

The sample size was calculated from an earlier study that compared the effect of two different drugs in menopausal women (as there are no studies on yoga). Using the pre-post mean and SD values from the vasomotor outcome variables from that study, an effect size of 0.52 was calculated.[32] Using this value of effect size and the values for 'alpha' and power at 0.05 and 0.8, respectively, a sample size of 108 was derived.

Of a total of 201 women experiencing menopausal symptoms screened, 120 women (married or single) who satisfied the inclusion criteria of (a) age between 40 and 55 years and (b) serum FSH level equal to or higher than 15 miu/ml on the sixth day of the menstrual cycle if she was menstruating regularly or at the time of recruitment if she had stopped menstruating or had irregular cycles were selected for the study. Women who had undergone hysterectomy with retained ovaries were also included. Exclusion criteria were (a) women who were practising yoga for a month or more, (b) women with no knowledge of English, (c) women with less than high school education, (d) women taking HRT, (e) women who underwent any surgery in past 3 months, (f) those with gynaecological problems like endometriosis, fibroids, ovarian cysts, prolapsed uterus etc., (g) women with other medical disorders (like hypertension, diabetes mellitus, hypo/hyperthyroidism) and (h) those on psychiatric medication.

Source of participants

The study was conducted at the Yoga University, Swami Vivekananda Yoga Research Foundation (SVYASA) in Bangalore city. The subjects were recruited through advertisements and giving talks about the benefit of these practices in women's organisations, clubs and organisations such as lioness clubs. They were also contacted through banners, newspaper advertisements and circulation of pamphlets apart from references through word of mouth. Some women were recruited through

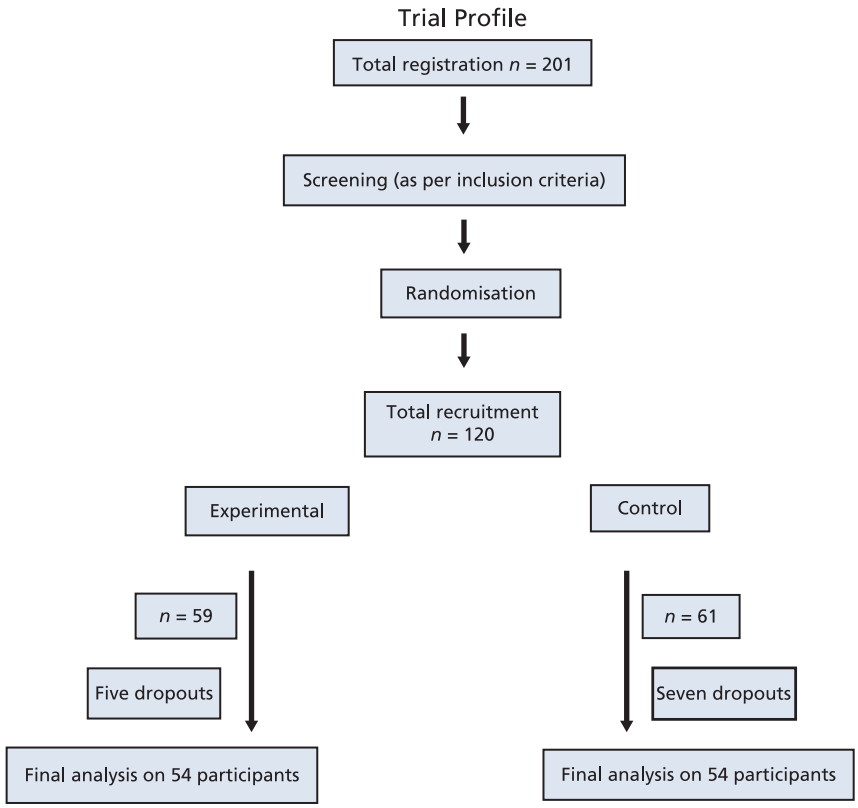

Figure 1. Trial profile.

gynaecological clinics as they consulted the doctor for their menopausal symptoms. In all, they were recruited from 14 different areas of Bangalore and classes were conducted at 14 nodal centres of SVYASA in different parts of the city.

Ethical clearance and consent

The institutional review board and ethical committee of the University Swami Vivekananda Yoga Research Foundation, Bangalore, sanctioned formal approval. The research staff answered queries and the participants then made an informed independent decision about participating in the study.

Design

This was a prospective, randomised controlled trial (RCT) wherein 120 participants were randomly divided into two groups: one group practised integrated approach of yoga therapy (IAYT) and the other practised a set of physical exercises. The women who satisfied the inclusion criteria were registered in different nodal centres by using pre-labelled envelopes to avoid selection bias; roll numbers were allotted and these numbers were randomly divided into two groups using a computer-generated random number table (http://www.randomizer.org) prepared for the specific number of participants available in the centre. Participants were assessed for the cognitive tests before and after 8 weeks of intervention. Both the yoga and control groups were given their respective set of practices for 1 hour of intervention per day, 5 days per week for 8 weeks, by specially trained instructors for both yoga and non-yogic physical exercise groups.

Blinding

As this is an interventional study, this could not be a double-blind study, but attempts were made to blind and mask wherever feasible to reduce the bias. The statistician who did the randomisation of the serial numbers of participants and the final analysis was blind to the source of the data. The answer sheets for the six-letter cancellation test (SLCT) and Punit Govil Intelligence Memory Scale (PGIMS) were coded and kept away for final analysis and were decoded only after complete analysis. The memory tests were administered by a psychologist (who was not involved in interacting with the participants) to the whole group before randomisation. Care was taken to arrange the timings and venue of the classes for the two groups suitably to avoid interaction and exchange of information and techniques among the participants of the two groups.

Assessments

Biochemical assessment

Serum FSH was used for initial screening of the subjects to satisfy one of the inclusion criteria. Blood samples were

collected in 'Anand Diagnostic Laboratory', Bangalore, on the sixth day of menstruation if the woman was menstruating regularly or at the time of recruitment itself if the woman had stopped menstruating or had irregular cycles. Estimation of FSH was carried out by electrochemiluminescence method using Roche Elecsys 2010 FSH kit. As per the standardisation, the normal range for the FSH values during follicular phase for regularly menstruating Indian women was 3.5–12.5 miu/ml. For the present study, a value of >15 miu/ml was considered the inclusion criterion.[33]

Vasomotor symptoms checklist

A checklist of three of the major symptoms of climacteric (vasomotor symptoms checklist [VCL] 1, hot flushes; VCL 2, night sweats and VCL 3, sleep disturbances), with severity scoring ranging from 0 to 3 (0 being absence of that symptom and 3 being severely suffering from that symptom), was used to assess the vasomotor symptoms for all participants.

Six-letter cancellation test

Six-letter cancellation test (SLCT) for adults is a paper-and-pencil test that uses a letter cancellation task that measures cognitive functions such as selective and focused attention, visual scanning as well as activation and inhibition of rapid responses. It consists of a test worksheet that specifies six target letters to be cancelled and has a 'working section', which consists of letters of the alphabet, arranged randomly in 22 rows and 14 columns. The participants are asked to cancel as many of the six target letters as possible in a specified time of 90 seconds.[34] The total number of cancellations and wrong cancellations are scored, and the net scores are calculated by deducting wrong cancellations from the total attempt. This test has been evaluated for its reliability and validity based on standard criteria. Reliability has been ascertained based on (a) temporal stability and (b) internal consistency.[35] The content validity of this test is adequate for the purpose for which it is intended.[36] The normal value for healthy Indian adults for SLCT is 38 ± 6.[34]

Tests of memory

PGIMS is a battery of ten memory tests, which measures the remote memory, recent memory, mental balance, two tests for attention and concentration (for digit memory and reverse digit memory), delayed recall, immediate recall, retention for similar pairs, retention for dissimilar pairs, visual retention and recognition test. The participant is supposed to write the responses to the questions asked by the administrator. Of the ten tests, eight tests are verbal, one test pertains to geometrical drawing and one on recognising objects. The reliability of this scale has been tested, and the norms for adults (>20 years) with no psychiatric/neurological illnesses are available. PGIMS is incorporated as one of the important tests to evaluate cognitive functions and organic brain dysfunctions. Administration takes 15–20 minutes per participant. The test retest reliability on 40 subjects ranged between 0.70 and 0.84 for organic psychotic groups, 0.48 and 0.84 for neurotic group. On the whole, however, an increase of four points was observed on repeated testing. For these two groups, split-half reliability was found to be 0.91 and 0.83, respectively.[37]

Yoga intervention

The yoga module used for the experimental intervention called integrated approach of yoga therapy (IAYT) for perimenopausal women was developed specifically for the purpose culled out from original scriptures (*Patanjali yoga sutras* and *Mandukya karika*) that highlight the concepts of a holistic approach to health management at physical, mental, emotional and intellectual levels with techniques to improve mental equilibrium and cognitive abilities. All these practices are aimed at one common effect, i.e. 'to develop mastery over modifications of the mind' (*chitta vritti nirodhah—Sage Patanjali*) through 'slowing down the rate of flow of thoughts in the mind' (*manah prashamana upayah yogah—Sage Vasishta*).

1. Sun salutation that includes a flow of 12 postures combined with breathing and chanting.[38]
2. Yogic breathing practices combined with simple body movements aimed to bring about a slow rhythmic breathing pattern that is the safest way to get mastery over the mind.[39] The principles involved in the technique of breathing were (a) slow down the rate of breathing while synchronising the body movements with breathing, (b) ensure that exhalation was longer than inhalation and (c) practice with full awareness of the touch of the flow of air through the nostril down the air passages.
3. Cyclic meditation (CM): Meditation is considered to be a part of yoga that works directly at the mind level (*Antaranga yoga*), which is a valuable tool to reach a state of alertful rest (calming down or silencing the internal dialogue). CM is a 35-minute practice that includes a combination of activating and pacifying practices to reach deeper quietitude and equilibrium than meditating in a single posture.[40]
4. The study group got lectures on physiology of menopause, healthy lifestyle including diet, exercise and yogic stress management techniques. Also, they were given yogic concepts to achieve a notional correction to help the participant (a) recognise her ability to tap the inner energy, which is made of immense bliss that could keep up her youthful feeling and allay the fears, (b) to restore her inbuilt freedom to change the responses to situations and (c) learn to touch the bed of silence, which is the source of all creativity that is essential for promotion of any cognitive function.[41]

Control intervention

The control group practised a set of exercise programme comprising easy (nonsweating) body movements supervised by physical trainers for the same duration of 1 hour daily, 5

days a week for 8 weeks. The exercise involved the stretching of the arms, legs and spinal twists, strengthening the muscles around knee joints, shoulder joints, neck and wrist joints. Lectures and individual counselling was given on conventional modern medical concepts about healthy lifestyle including diet, exercise and physiology of menopause and stress management techniques. Details are given in Table 1.

Data extraction

Data of 108 (leaving the 12 dropouts of 120) participants were scored as per the instructions in the manual by a psychologist and were analysed by the statistician using SPSS version 10.0 (SPSS Inc., Chicago, IL, USA). The test of normality was carried out using Kolmogorov–Smirnov test as the sample size was above 50. Because the data were not normally distributed, nonparametric tests were used: Mann–Whitney test for between group comparison and Wilcoxon signed-ranks test for within group comparison. The baseline values for all the variables in both the groups were compared using Mann–Whitney test. Effect sizes were calculated to measure the magnitude of difference of parameters between the two groups.[42] Correlations were checked by Spearman's correlation coefficient, as the data were non-normal. For the design of this study (one within-subjects and one between-subjects factor), there were no ancillary analyses.

Results

The flowchart describes the trial profile (Figure 1). Of the 120 participants, there were 12 dropouts, 5 in the yoga and 7 in the control group due to (a) husband's ill health, (b) transfer to other cities and (c) unexpected events in the family.

Table 2 shows demographic data. At baseline, the data were not significantly different between the two groups for FSH and body mass index ($P = 0.11$ and 0.07, respectively, Mann–Whitney test), for SLCT ($P = 0.528$) and all subtests of PGIMS (P value for test I, 0.39; II, 0.49; III, 0.24; IV (i), 0.43; IV (ii), 0.01; V, 0.625; VI, 0.59; VII, 0.72; VIII, 0.98; IX, 0.92 and X, 0.06).

Table 3 shows the results of VCL. The scores on all three symptoms in VCL reduced significantly in yoga group with a nonsignificant change in control group (except night sweats). Mann–Whitney test showed a trend of significant ($P = 0.06$) difference between groups in night sweats only.

Table 4 shows the results of the SLCT and PGIMS. The values of SLCT improved in both groups. Mann–Whitney test showed significantly greater improvement ($P < 0.001$) in yoga group (effect size 1.16) than the control group (effect size 0.6).

The results for the different cognitive functions of the PGIMS tests are as follows:

- PGIMS-I (remote memory): Both groups showed significant increase ($P = 0.001$, Wilcoxon test). There was greater improvement ($P < 0.001$, Mann–Whitney test) in the yoga (effect size 0.84) than in the control group (effect size 0.58).
- PGIMS-II (recent memory): There was no change observed in this test because the effect sizes were very low (0.01, Mann–Whitney test) in both groups.
- PGIMS-III (mental balance): Yoga group showed significant increase ($P < 0.001$, Wilcoxon test), whereas the control group showed no change ($P = 0.39$). There was greater improvement ($P < 0.001$, Mann–Whitney test) in the yoga group (effect size 1.66) than in the control group (effect size 0.17).
- PGIMS-IV (i) (attention and concentration): Both groups showed significant increase with greater improvement ($P < 0.001$, Mann–Whitney test) in the yoga (effect size 0.74) than in the control group (effect size 0.34).
- PGIMS-IV (ii) (attention and concentration): Both groups showed significant increase ($P = 0.001$, Wilcoxon test). There was significant difference between ($P < 0.001$, Mann–Whitney test) yoga (effect size 0.61) and control groups (effect size 0.63).

Table 1. Practices used for the two intervention groups

	Experimental group	Control group
1	**Lectures on IAYT, diet, emotion culture, concepts and management of stress according to yogic practices (15 minutes)**	**Lectures on importance of exercise, role of diet in menopause, stress, stress physiology (15 minutes)**
2	**Breathing exercises: (10 minutes)**	**Loosening practices: (10 minutes)**
	Hasta āyāma śvasanam (hands in and out breathing)	Twisting
	Hasta vistāra śvasanam (hands stretch breathing)	Forward and backward bending
	Gulpha vistāra śvasanam (ankle stretch breathing)	Side bending
	Vyāghra śvasanam (tiger breathing)	Spinal twist
	Setu bandha śvasanam (bridge posture breathing)	Toe walking
3	***Suryanamaskara* (sun salutation) (10 minutes)**	**Brisk walk (10 minutes)**
4	***Avartan dhyanam* (CM) (25 minutes)**	**Supine rest (25 minutes)**

Table 2. Demographic data

Serial number	Variables		Yoga		Control
1	**Age (mean ± SD)**		49 ± 3.6		48 ± 4
	Number between 40–45 (years)		13		14
	Number between 46–50 (years)		22		23
	Number between 51–55 (years)		19		17
2	**W/H**		14/40		9/45
3	**Body mass index (mean ± SD)**		28 ± 3.4		29 ± 4
4	**V/NV**		43/11		45/9
		n	**FSH (mean ± SD) miu/ml**	***n***	**FSH (mean ± SD) miu/ml**
5	**A: premenopausal**	14	43.88 ± 21.64	16	37.94 ± 17.52
	B: irregular menstruation	17	47.16 ± 23.45	20	38.72 ± 14.94
	C: menopausal	9	83.65 ± 43.59	7	56.9 ± 20.77
	D: postmenopausal	14	59.5 ± 18.67	11	66.81 ± 21.14
6	**FSH (miu/ml) mean ± SD**		56 ± 29.9		47 ± 21.5

V/NV, vegetarian/non-vegetarian; W/H, working/housewives.A, women having regular menstruation; B, irregular menstrual cycles, C, menopause attained between 1 year and 3 years ago; D, menopause attained more than 3 years ago. There is no significant difference between groups in all the variables at baseline.

- PGIMS-V (delayed recall): The yoga group showed significant increase ($P < 0.001$, Wilcoxon test), whereas the control group showed no improvement ($P = 0.36$). There was greater improvement ($P < 0.001$, Mann–Whitney test) in the yoga (effect size 1.47) than in the control group (effect size 0.18).
- PGIMS-VI (immediate recall): The yoga group showed significant increase ($P < 0.001$, Wilcoxon test), but the control group showed significant change ($P = 0.015$). There was greater improvement ($P < 0.001$, Mann–Whitney test) in the yoga (effect size 1.51) than in the control group (effect size 0.42).
- PGIMS-VII (verbal retention of similar pairs): There was no change in both the groups ($P = 0.18$ in yoga group, $P = 0.25$ in control group in Wilcoxon test). There was no difference between the groups ($P = 0.56$, Mann–Whitney test).
- PGIMS-VIII (verbal retention of dissimilar pairs): Both groups showed significant increase ($P < 0.001$ in yoga group, $P = 0.009$ in control group in Wilcoxon test). The magnitude of change within group was more in the control group (effect size 1.23) than that in the yoga group (effect size 0.90).
- PGIMS-IX (visual retention): There was significant increase in the yoga group ($P < 0.001$, Wilcoxon test), whereas no change in the control group ($P = 0.39$). There was greater improvement ($P = 0.01$, Mann–Whitney test) in the yoga (effect size 0.70) than in the control group (effect size 0.14).
- PGIMS-X (recognition): Both groups showed significant increase ($P = 0.001$, Wilcoxon test). There was greater improvement ($P = 0.001$, Mann–Whitney test) in the yoga (effect size 0.58) than in the control group (effect size 0.28).

Table 3. Results of vasomotor symptom checklist (VCL)

Variables	Y		C		Y	C	Y	C	Significant Y and C *P***	Effect size Y and C
	Pre mean ± SD	**Post mean ± SD**	**Pre mean ± SD**	**Post mean ± SD**	**Significant *P****		**Effect size pre-post**			
VCL 1	1.02 ± 1.02	0.50 ± 0.77	0.78 ± 0.84	0.70 ± 0.74	<0.001	0.39	0.65	0.10	0.08	0.26
VCL 2	0.83 ± 1.06	0.43 ± 0.69	0.85 ± 0.90	0.65 ± 0.73	<0.001	0.04	0.62	0.27	0.06	0.31
VCL 3	0.74 ± 0.99	0.44 ± 0.72	0.85 ± 0.98	0.74 ± 0.91	001	0.18	0.49	0.14	0.08	0.36

C, control group; VCL 1, hot flushes; VCL 2, night sweats; VCL 3, disturbed sleep; Y, yoga group.Mean ± SD and *P* values for within and between groups and effect sizes are calculated for vasomotor symptoms before and after 8 weeks of intervention. VCL: There is significant improvement in yoga group and nonsignificant improvement in control group except night sweats.
*Wilcoxon *P* value.
**Mann–Whitney *P* value.

Table 4. Results of SLCT and PGIMS

Variable	Groups	Pre mean ± SD	Post mean ± SD	Within group, *P**	Effect size pre-post	Between Y and C, *P***	Effect size Y and C	Normative data
SLCT	Y	27.43 ± 6.91	35.31 ± 6.72	<0.001	1.16	<0.001	0.8	30 ± 6
	C	26.48 ± 6.37	30.19 ± 6.63	<0.001	0.6			
PGIMS-I	Y	5.43 ± 0.66	5.87 ± 0.34	<0.001	0.84	<0.001	1.55	5.78 ± 0.52
	C	5.52 ± 0.67	5.17 ± 0.54	0.001	0.58			
PGIMS-II	Y	4.94 ± 0.23	4.94 ± 0.23	0.83	0.00	0.080	0.01	4.91 ± 0.29
	C	5 ± 0.51	4.93 ± 1.15	0.439	0.08			
PGIMS-III	Y	4.93 ± 1.15	6.52 ± 0.72	<0.001	1.66	<0.001	1.36	5.69 ± 2.64
	C	5.19 ± 0.93	5.33 ± 0.7	0.394	0.17			
PGIMS-IV (i)	Y	5.39 ± 1.04	6.2 ± 1.14	<0.001	0.74	<0.001	0.94	8.46 ± 1.91***
	C	5.24 ± 1.11	4.83 ± 1.3	0.014	0.34			
PGIMS-IV (ii)	Y	3.57 ± 1.09	4.19 ± 0.95	<0.001	0.61	<0.001	0.58	
	C	4.17 ± 1.15	3.56 ± 0.74	0.001	0.63			
PGIMS-V	Y	8.11 ± 0.88	9.33 ± 0.78	<0.001	1.47	<0.001	1.20	6.99 ± 1.53
	C	8.02 ± 0.9	8.17 ± 0.8	0.363	0.18			
PGIMS-VI	Y	9.26 ± 1.51	11.13 ± 0.89	<0.001	1.51	<0.001	0.93	7.41 ± 1.98
	C	9.41 ± 1.5	9.98 ± 1.21	0.015	0.42			
PGIMS-VII	Y	4.93 ± 0.26	4.98 ± 0.14	0.18	0.24	0.56	0.10	4.36 ± 0.78
	C	4.91 ± 0.29	4.96 ± 0.19	0.257	0.20			
PGIMS-VIII	Y	11.48 ± 2.67	13.46 ± 1.59	<0.001	0.90	<0.001	0.73	11 ± 3.59
	C	9.28 ± 2	11.85 ± 2.18	0.009	1.23			
PGIMS-IX	Y	10.85 ± 2.46	12.35 ± 1.76	<0.001	0.70	0.01	0.26	8.2 ± 3.28
	C	11.43 ± 2.46	11.76 ± 2.1	0.39	0.14			
PGIMS-X	Y	8.13 ± 2.37	9.37 ± 1.89	<0.001	0.58	0.001	0.37	8.36 ± 1.61
	C	7.57 ± 1.53	8.59 ± 1.4	<0.001	0.28			

C, control group; Y, yoga group.Mean ± SD and *P* values are calculated for PGIMS (ten subtests) using Wilcoxon *P* value and Mann–Whitney *P* value. Variables: PGMIS-I, remote memory; PGIMS-II, recent memory; PGIMS-III, mental balance; PGIMS-IV (i), attention and concentration (i); PGIMS-IV (ii), attention and concentration (ii); PGIMS-V, delayed recall; PGIMS-VI, immediate recall; PGIMS-VII, verbal retention (i); PGIMS-VIII, verbal retention (ii); PGIMS-IX, visual retention; PGIMS-X, recognition test. There was greater improvement in the yoga group than the control group in SLCT: improvement in yoga is better than control group and in all subtests of memory except II and VII and the control showed better effect size than yoga group in VIII test.

*Wilcoxon *P* value.

**Mann–Whitney *P* value.

***This score is given in the PGIMS manual combining both attention and concentration (i) and (ii).[37]

Discussion

Cognitive functions and vasomotor symptoms were assessed in this randomised control prospective two-arm interventional study on 108 perimenopausal women (age 40–55 years). Mann–Whitney test to compare the two groups showed that there was significantly better improvement in the yoga group compared with the control group in hot flushes and attention task in SLCT. In PGIMS, there was significant improvement within both groups with significant difference between groups, the effect sizes being better in the yoga group than in the control group in PGIMS-I (remote memory), III (mental balance), IV (i and ii) (attention and concentration [i and ii]), VI (immediate recall) and X tests (recognition test). There was significant improvement only in yoga group and not in control group with significant difference between groups in PGIMS-V (delayed recall) and PGIMS-IX (visual retention). In PGIMS-VIII (verbal retention-ii), both groups improved with higher effect size in control group and significant difference between groups. The PGIMS-II (recent memory) and PGIMS-VII (verbal retention-i) tests showed no change in both the groups.

Comparison with other studies

The preferred option for complementary and alternative medicine (CAM) by women[43] has triggered interest into research on these therapies. Of the four studies (two on cognitive behavioural therapy (CBT) and two on relaxation response), only one was a well-designed RCT on 33 women taking relaxation response training compared with a reading group, demonstrated a significant reduction in hot flush intensity, tension-anxiety and depression in perimenopausal women after 10 weeks of intervention.[44] Our recent randomised control study in the Indian population has shown the

reduction in vasomotor and other menopausal symptoms 8 weeks after the supervised practice of the integrated approach of yoga therapy as measured by Greene climacteric scale (GCS) with a significant difference between groups with higher effect sizes in the yoga group than the control group in all factors of GCS.[45]

There are no studies on changes in cognitive functions with nonpharmacological therapies. In comparison, the present study on IAYT that combined both body and mind level practices of self-management (lifestyle change) has shown significant improvement in both frontal lobe and memory functions for the first time through a nonpharmacological intervention. A study on the interaction of HRT and physical activity (PA) showed a beneficial relationship between PA and cognitive performance in postmenopausal women irrespective of HRT use.[46] These studies tend to point out that the self-corrective techniques that the person puts in by applying her mind, be it a PA or IAYT, influences the cognitive functions.

Mechanism

SLCT measures the attention capacity, a frontal lobe function. A self-control study on the effect of CM (that has been incorporated in the IAYT for the experimental group in the present study) has shown significant increase in SLCT scores immediately after CM, suggesting enhanced efficiency and shorter time in cortical neural processing.[47]

Electrophysiological studies during cognitive functions of the brain have reported that P300 (a specific positive wave that occurs at the 300th millisecond in the tracing of evoked potential) is generated from hippocampus and other associated areas.[48] Estrogen receptors have been detected in the pyramidal cells nuclei of the ventral hippocampus and other specific brain areas that are involved in learning, memory and cognition. Cyclic changes in synaptic genesis and spine density of the hippocampus have been shown to be induced by estrogen,[18] which gets depleted in this age; hence, memory functions may undergo a declining change. However, contrary to our expectation, estrogen replacement therapy (ERT) *per se* may not improve the cognitive functions.[46] A study on the effect of CM observed that there was reduction in the peak latencies of P300 after CM compared with the prevalues that suggest enhanced efficiency and shorter time in processing. Also, the P300 peak amplitudes after CM were higher compared with the prevalues, suggesting an increased in attentional resources.[49] Thus, it may be hypothesised that the improvement in the cognitive functions observed in this study is due to the effect of yoga in bringing about better information processing in the subtle layers of the frontal lobe. This in turn could be due to the alertful rest that CM may offer and may not be related to estrogen-mediated response. CM developed on a subtle principle suggested by a rarely used authentic scripture (*Mandukya karika*) that includes stimulation–relaxation combination for achieving deeper degree of rest. This principle is made practical by knitting yoga postures interspersed with periods of supine relaxation and has been shown to provide deeper degree of rest than simple supine rest or the commonly used meditative techniques.[50]

Novelty, limitations and suggestions for future work

This is the first RCT that has looked at cognitive functions after yoga practice in climacteric. An objective measure, serum FSH level, was used as the inclusion criterion rather than only the subjective symptoms of menopausal rating scale. Control group also had the supervised practices for the same duration as the experimental group.

One limitation of the study with regard to external validity was that because the tests were in English, the sample was restricted to women with knowledge of the English language. Thus, our sample should be taken to be fairly representative of women in urban India.

Other limitations were that the estradiol levels were not measured. Although we have used FSH levels as the only objective inclusion criterion,[51] it will be interesting to see the effect of long-term practice of IAYT on FSH and estradiol levels.

Suggestions for future work

Functional studies to look at the changes in neurohormonal changes in the brain during IAYT in climacteric would throw light on the mechanism.

Conclusions

Thus, the present study has shown that the practice of IAYT for 8 weeks improves the cognitive functions like attention, concentration, mental balance, verbal retention and recognition abilities in menopausal women compared with physical exercises.

The control group practices that comprised of physical exercises also showed improvement in many of the memory functions similar to earlier studies on the efficacy of PA in perimenopausal women.[46] Thus, the present study shows the superiority of yoga over PA in improving the cognitive functions that could be attributed to emphasis on correctness in breathing, synchronising breathing with body movements, relaxation and mindful rest.

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Contribution to authorship

R.C.: Involved in designing, conducting and writing the manuscript. R.N.: Regular supervision of the study in all phases

including the manuscript writing. V.P.: Gynaecologist who assessed the clients for recruitment, contributed in all phases of the study by regular supervision and guidance. Inputs for the manuscript writing. H.R.N.: Guidance and advice on the yoga component of the design, training the therapists and writing the manuscript.

Details of ethics approval

Formal approval was sanctioned in their letter SVYASA/PHD/ETHICS/04-3011 dated 30 November 2004 by the institutional review board and ethical committee of the University Swami Vivekananda Yoga Research Foundation, Bangalore.

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