Yoga/Meditation and Physical Exercises and Associated Cognitive Function Among Older Adults: Findings from Baseline Wave of the Longitudinal Aging Study in India

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Abstract

The treatment of cognitive deficits including dementias through the medical model has been limited due to high cost of therapy, adverse effects of the drugs used, and lack of efficacy in several cases. This chapter explored the association of yoga/meditation and moderate/vigorous physical activities with late-life

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cognitive functioning and the sex differences in those associations. The study was conducted on a sample of older adults aged 60 years or older, drawn from the baseline wave of Longitudinal Ageing Study in India (2017–2018). Significance level of bivariate associations between explanatory variables and outcome variable (overall cognitive score) was assessed using simple linear regression. Bar graphs and box plots are used to present the sex-stratified estimates. Multivariable linear regression was employed to test the study hypotheses. Older participants who practiced yoga/meditation reported moderate or vigorous physical activity in this study were associated with better cognitive function compared to their respective counterparts. Significant sex differences were also observed in these associations with a female disadvantage. Thus, it would be crucial for policymakers to advocate health-promotional programs such as yoga/meditation and physical exercises that enhance cognitive abilities of older individuals and women in particular and ensure active aging.

Keywords

Yoga/meditation · Physical exercise · Cognitive function · Older adults

1 Introduction

It is widely recognized that older adults are the fastest growing segment of the population worldwide. Across the world regions, Asia is likely to witness the most rapid increase in older citizens between now and 2050. In 2016, a proportion of 12.4 percent of the population in Asia was 60 years or older, and this is projected to increase to more than a quarter or 1.3 billion people by 2050 (ESCAP, 2020). With the increase in aged population, new challenges emerge that include their increased need for care especially in terms of onset of cognitive decline and dementia (World Health Organization, 2019). Therefore, geriatric researchers have become concerned with identifying factors that might maintain a good cognitive health or prevent cognitive deficits among older population.

Previous studies found that mental illnesses when coupled with some form of physical activity can result in better outcomes (Cherubal et al., 2019; Warburton & Bredin, 2017). The potential role of physical activity in enhancing the cognitive functions in old age is also documented in multiple studies and concluded that there is evidence on positive effects of exercise on brain health (Etnier et al., 2019). Although the mechanism by which physical activity impacts cognitive decline remains unclear, a review of several cross-sectional, longitudinal, and interventional studies has suggested that physical activities and exercises are promising non-pharmaceutical intervention for older adults in preventing age-related cognitive decline (Bherer et al., 2013). Similarly, observational cohort studies with longer time spans for physical activity also found such activities as important determinants of cognitive function (Blondell et al., 2014; Hamer & Chida, 2008; Weuve et al., 2004).

2 Theoretical Background

All meditation practices involve two attention-guided practices. The first one is focused attention centered on a given object, and the second one ensures that the practitioner stays silent and passively observes the thoughts (Basso et al., 2019; Reangsing et al., 2021). Yoga is one among such practices. It refers to an ancient practice and includes complex activities that promote physical, spiritual, and mental well-being (Panjwani et al., 2021). It is documented that yoga, prayer, and other meditation practices have physical, cognitive, and emotional components and are more effective in bringing mental health benefits than other non-pharmacological interventions (Johnston, 2021; Panjwani et al., 2021). Previous reviews indicated that yoga-based interventions have some positive evidence in reducing mental stress, improving attention, executive functions, and memory of cognition (Chobe et al., 2020; Cramer et al., 2018; Mooventhan & Nivethitha, 2017). Similarly, yoga and yoga therapy are known to alleviate neurological problems and neurodevelopmental disorders and improve the cognitive abilities of individuals (Rocha, 2012; Ross & Thomas, 2010; Soccalingam et al., 2020). Several randomized clinical trials of yoga-based intervention showed improvements in multiple domains of cognition including memory, executive functioning, and processing speed for the yoga group in comparison to the control group after adjusting for baseline cognition and other characteristics (Gothe et al., 2017; Hariprasad et al., 2013; Hoy et al., 2021). A recent systematic review with meta-analysis in India reported that yoga-based interventions are safe and effective for older individuals to maintain their cognitive functions and prevent age- and disease-related cognitive decline (Bhattacharyya et al. 2021a). Similarly, findings from a study in Japan on a "yoga-plus" intervention which consisted of yoga and other mixed exercises revealed that the program improved the cognitive and physical functions of older participants (Hishikawa et al., 2019).

The treatment of cognitive deficits including dementias through the medical model has been limited due to high cost of therapy, adverse effects of the drugs used, and lack of efficacy in several cases (Casey et al., 2010). Since mind-body practices have emerged as an alternative strategy to manage cognitive problems and positively impact cognition, there is a paucity of population-based studies on this aspect. On the other hand, aging is characterized by a "gender paradox" that refers to higher life expectancy and increased morbidity in women compared to men (Arber & Cooper, 1999; Ory & Warner, 1990). Similarly, studies conducted in India point to a wider gender gap in lower levels of physical activity in the population attributed to gendered social norms and practices (Adlakha & Parra, 2020). Again, significant sex differences in cognitive function associated with physical activity are demonstrated in a recent study and showed that women may benefit more from physical activity in terms of late-life cognitive health (Kumar et al., 2022).

Thus, the current study explored the association of yoga/meditation and moderate/vigorous physical activities with cognitive functioning and the related sex differences among community-dwelling older individuals using large nationally

representative population-based survey data in India. The study hypothesized that (i) yoga and meditation are positively related to cognitive function in late life, and (ii) moderate and vigorous physical exercises are associated with better cognitive function among older adults.

3 Empirical Strategy

3.1 Sample

A cross-sectional study was conducted on data that were drawn from the baseline Longitudinal Ageing Study in India (LASI) that was collected during 2017–18. It is a nationally representative survey that covers a baseline sample of 72,250 individuals aged 45 and above and their spouses regardless of age (from 42,949 households), including 31,464 older persons aged 60 and above and 6749 oldest-old persons aged 75 and above from all States and Union Territories (UTs) of India (excluding Sikkim). The main objective of the survey was to study the socioeconomic status, health, and well-being of older adults in India. The current study is conducted on eligible respondents aged 60 years and above with a total sample of 26,175 older adults (men-13,126 and women-13,049).

3.2 Procedure

An individual survey schedule was administered to each consenting respondents (after collecting written and verbal informed consent) in the sampled households. The LASI employed computer-assisted personal interview (CAPI) techniques to record the responses of survey participants, with questions asked of respondents in a face-to-face interview. The overall household response rate was 96 percent, and the individual response rate was 87 percent. The survey sample is representative at the national and state and union territory levels and is reasonably harmonized with the survey instruments being fielded in health and retirement studies that are ongoing in 46 other countries around the world, facilitating the conduct of meaningful cross-state along with cross-national comparisons (see "Concordance across Surveys" at Gateway to Global Aging Data (https://g2aging.org/concordance) for detailed concordance information) (Bloom et al., 2021). The sampling was based on a multistage stratified cluster sample design, which includes three distinct selection stages in rural areas and four distinct selection stages in urban areas. The detailed methodology, with the complete information on the survey design and data collection, was published in previously published studies and the survey report prepared by the International Institute for Population Sciences (IIPS), Mumbai, in collaboration with the Harvard School of Public Health, the University of Southern California, the United Nations Population Fund (UNFPA), and the National Institute on Ageing (Bloom et al., 2021; International Institute for Population Sciences (IIPS), NPHCE, MoHFW, 2020; Muhammad et al., 2021). The data were anonymized before its use,

and all the methods were performed in accordance with relevant guidelines and regulations. The Indian Council of Medical Research (ICMR) extended the necessary guidelines and ethics approval for undertaking the LASI survey.

3.3 Definition and Measurements

The current study focused on exploring the association of several groups of activities with cognitive health among older individuals. The following sections explain the measurement of outcome and explanatory variables in this study.

3.4 Outcome Variable (Cognitive Function)

The LASI collected the information related to different cognition measures in six dimensions including memory, orientation, arithmetic functioning, executive functioning, and object naming. The LASI survey adapted these measures from the Mini-Mental State Examination (MMSE) (Juva et al., 1997), and the cognitive module of the Health and Retirement Study, the China Health and Retirement Longitudinal Study (CHARLS), and the Mexican Health and Aging Study (MHAS) (Blankson & McArdle, 2014; Saenz et al., 2021). Memory was measured using immediate word recall and delayed word recall. Orientation was measured using time and place measures. The arithmetic function was measured through backward counting, a serial seven subtraction task and a task involving two computations (Blankson & McArdle, 2014; International Institute for Population Sciences (IIPS) et al., 2020). Additionally, paper-folding (folding a piece of paper according to instructions), pentagon-drawing (drawing intersecting circles), and object-naming methods were followed to measure the cognitive functions among older adults (Saenz et al., 2021) (Cronbach's alpha: 0.70). The overall score of composite index of cognitive function ranged between 0 and 43, and a higher score indicated better cognitive functioning. The cognitive function score in our study is created based on the scoring of different cognitive subdomains, including immediate word recall (0–10 points) and delayed word recall (0–10 points); orientation related to time (0–4 points) and place (0–4 points); arithmetic ability based on serial 7 s (0–5 points), computation (0–2), and backward counting from 20 (0–2 points); executive functioning based on paper folding (0–3) and pentagon drawing (0–1); and object naming (0–2). In the current analysis, the respondents who received assistance during the cognition module were excluded. The details of the measurement of cognitive functioning across domains are illustrated in Table 1.

3.5 Main Exposure Variables

In the current study, there were three exposure variables which include yoga/meditation, moderate physical activity, and vigorous physical activity.

Table 1 Different domains of measuring cognitive functioning among older adults in India used in LASI, 2017–2018

Domain	Measure	Measurement	Range
Memory: 0-20	Immediate word recall	Interviewer read out a list of 10 words, and respondents were asked to repeat the words	0–10
	Delayed word recall	Respondents were asked to recall the same words read out for immediate recall after some time	0–10
Orientation: 0-8	Time	Respondents were asked to state today's date, month, and year and day of the week. For each question, the score was 0 or 1. Correct responses received 1 point, and incorrect responses received 0. The total score for time was 0–4	0–4
	Place	Orientation toward place was captured based on place of interview, name of the village, street number/colony name/ landmark/neighborhood, and name of the district Each correct response scored 1 point. The total score ranged from 0 to 4	0–4
Arithmetic function: 0-9	Backward counting	Respondents were asked to count backward as quickly as possible from the number 20. The respondents were asked to stop after correctly counting backward from 20 to 11 or from 19 to 10 Correct counting received 2 points; counts with a mistake received 1 point. Those who could not count received 0 points	0–2
	Serial 7	Respondents were asked to subtract 7 from 100 in the first step and asked to continue subtracting 7 from the previous number in each subsequent step for five times. Each correct response received 1 point	0–5
	Computation	This test involved the mathematical operation of division. Respondents were asked to compute the net sale price of a product after considering a discount sale of half of the original price	0–2
Executive function: 0–4	Executive (paper folding)	This is a three-stage command task. The respondents were instructed to take a piece of paper from the interviewer, turn it over, fold it in half, and give it back to the interviewer. Three points were given if each task was completed successfully	0–3
	Pentagon drawing	Visio-construction is the ability to coordinate fine motor skills with visiospatial abilities, usually by reproducing geometric figures. Respondents were asked to copy two overlapping pentagons and scored one point for a correct drawing	0–1
Object naming: 0–2		The interviewer points to a specific object and asks the respondent to name it. Two objects were pointed out and one point was given for each correct response	0–2
Cognition	Composite cognitive index	Combined score of memory (total word recall), orientation, arithmetic function, executive function, and object naming	0–43

Source: LASI India Report, 2020

Yoga/meditation: The yoga/meditation variable was generated using the survey question, How often do you engage in the activities such as yoga, meditation, asana, pranayama, or similar? The variable was dichotomized as yes (every day, more than once a week, once a week, and one to three times in a month), and no (hardly ever or never).

Moderate physical activity: Moderate physical activity is measured through the question, "How often do you do activities such as cleaning house, washing clothes by hand, fetching water or wood, drawing water from a well, gardening, bicycling at a regular pace, walking at a moderate pace, dancing, floor or stretching exercises?" The responses were coded into binary as yes (every day, more than once a week, once a week, and one to three times in a month), and no (hardly ever or never).

Vigorous physical activity: The question through which physical activity was assessed was "How often do you take part in sports or vigorous activities, such as running or jogging, swimming, going to a health centre or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling with loads"? And the vigorous physical activity was coded as yes (every day, more than once a week, once a week, and one to three times in a month), and no (hardly ever or never).

3.6 Other Covariates

The following sociodemographic variables were included in the current analyses as possible confounders in the associations between exposure variables and the outcome variable. Age was categorized into age groups of 60–69 years, 70–79 years, and 80+ years. Sex was coded as male and female. Educational status was coded as no, primary, secondary, and higher. Working status was coded as never worked, currently not working, working, and retired. Marital status was coded as currently married, widowed, and others. Others included divorced/separated/never married. Types of living arrangements were categorized into living alone, living with spouse, living with spouse and children, and living with others. The last category consists of various combinations of older adults' coresidential living, i.e., living with spouse and other relatives, and living with children and/or other relatives.

Furthermore, several health-related variables that may potentially moderate the associations between exposure variables and outcome variable or be associated with the outcome variable are also included in this study. Following the previous studies (Sampson et al., 2009; Zhou et al., 2020), survey questions based on participation in social activities were assessed to generate the variable, social participation. The activities including eating out of the house, going to park/beach, visiting relatives/friends, attending cultural performances/shows/cinema, attending religious functions/events, and attending community/political/organization group meetings were included and recoded as 0 "yes" and 1 "no" (0 = at least once in a month, 1 = rarely or never). Tobacco use and alcohol consumption were coded as no and yes referring to ever use of tobacco or alcohol (Srivastava et al., 2021). Self-rated health was available on a scale of five which represents very good, good, fair, poor, and very poor. Activities of daily living (ADL) and instrumental activities of daily living (IADL) were coded from 0 to 3 plus based on the number of difficulties. The ADL

activities that were expected to last more than 3 months included dressing, including putting on slippers, shoes, etc., walking across a room, bathing, eating, and using the toilet, including getting up and down. On the other hand, IADL activities included preparing a hot meal (cooking and serving), shopping for groceries, making a telephone call, taking medications, doing work around the house or garden, managing money (such as paying bills and keeping track of expenses), and getting around or finding an address in unfamiliar places that were expected to last more than 3 months. A score of 0 represents no difficulty whereas a score of 3+ refers to more than three functional difficulties (Muhammad & Rashid, 2022).

Household level factors that are adjusted in the analysis included monthly per-capita consumption expenditure (MPCE) quintile that was assessed using household consumption dat. Data on consumption expenditure in the LASI survey are collected using the abridged version of the consumption schedule of the National Sample Survey (NSS). Sets of 11 and 29 questions on the expenditures on food and nonfood items, respectively, were used to canvas the sample households. Food expenditure was collected based on a reference period of 7 days, and nonfood expenditure was collected based on reference periods of 30 days and 365 days. Food and nonfood expenditures have been standardized to the 30-day reference period (International Institute for Population Sciences (IIPS), NPHCE, MoHFW, 2020). The variable was divided into five quintiles of poorest, poorer, middle, richer, and richest; religion, that was recoded as Hindu, Muslim, and Others; and caste that was recoded as Scheduled Caste/Scheduled Tribe (SC/ST), Other Backward Class (OBC), and others. OBC is a collective term used by the Government of India to classify castes which are educationally or socially disadvantaged. The SC and ST are officially designated groups of people among the most disadvantaged socioeconomic groups in India. The terms are recognized in the Constitution of India, and the groups are designated in one or other of the categories. “Others” caste category refers to mainly higher caste groups who are socioeconomically advantaged. Community-related variables included place of residence (urban and rural) and regions (North, Central, East, Northeast, West, and South).

3.7 Analytic Approach

We reported descriptive statistics to present the sample characteristics and to show the overall mean score of cognitive functioning along with several socioeconomic and health characteristics of older adults. Significance level of bivariate associations between explanatory variables and outcome variable (overall cognitive score) was assessed using simple linear regression. Bar graphs and box plots are used to present the sex-stratified prevalence of yoga/meditation and physical activities and estimates of sex-stratified bivariate associations. Box plots are presented separately for each of the main exposure variables. Further, multivariable linear regression analysis was used to test the research hypotheses of this study. The results are presented in the form of unadjusted and adjusted nonstandardized beta coefficients with a 95 percent confidence interval (CI) and standardized beta coefficients. Survey weights were applied to account the population level estimates. STATA version 14.2 has been used throughout the analysis.

4 Empirical Results

4.1 Sociodemographic and Health Characteristics of Older Adults, LASI

Table 2 represents the sample characteristics. Among the respondents, 16.43 percent practiced yoga or meditation at least once a month. A proportion of 10.04 percent reported moderate physical activity, and a proportion of 32.23 per cent reported vigorous physical activities. A proportion of 63.43 percent of the study sample were aged 60–69 years and 8.55 per cent aged 80+ years. Men constituted 50.15per cent of the total interviewed respondents. Of all sampled respondents, almost half (49.85 percent) had no education and 30.96 percent had a secondary or higher education. A proportion of 30.02 percent were currently engaged in the work-force, and 31.32 percent were widowed at the time of the interview. Almost one-fourth of older individuals were living alone or with spouse, and 26 percent preferred separate living. The proportion of respondents reporting social participation was 58.30 percent. Health-related variables considered, more than 20 percent reported a poor or very poor SRH, 6.19 percent and 22.36 per cent reported 3+ ADL and IADL difficulties, respectively. Nearly three-fourth of the sample belonged to Hindu religion, and 64.53 percent were from rural areas.

4.2 Sex Differences in Engaging in Yoga/Meditation and Physical Activity

Figure 1 presents the percent distribution of yoga/meditation, moderate physical activity, and vigorous physical activity by sex of the respondents. A proportion of 17.85% of older men reported they have engaged with yoga/meditation activities in comparison to 12.68% of older women. The proportion of older men who engaged in moderate physical activity was significantly higher than older women who engaged in moderate physical activity (11.61% vs 6.73%). Similarly, the proportion of older men who engaged in vigorous physical activity was significantly higher than older women who engaged in vigorous physical activity (39.18% vs 22.71%).

4.3 Sex Differences in Cognitive Function by Yoga/Meditation and Physical Activity

Figures 2a–c present the mean cognitive score of older adults engaged in yoga/meditation and physical activity stratified by sex. Older men who engaged in yoga/meditation had higher cognitive score (mean: 26.10, CI: 25.99–26.22) compared to older women who engaged in yoga/meditation (mean: 28.59, CI: 28.37–28.81). Similarly, older men who engaged in moderate/vigorous physical activity had higher mean score of cognition in comparison to older women who engaged in such activities.

Table 2 Sample characteristics and mean cognition score by selected variables

Background variables	Number (%)[a]	Mean cognition score (0–43)[b]	*p*-value[c]
Yoga/meditation			
No	21,840 (83.57)	23.55	Ref.
Yes	4294 (16.43)	26.97	<0.001
Moderate physical activity			
No	23,375 (89.96)	24.13	Ref.
Yes	2609 (10.04)	27.95	<0.001
Vigorous physical activity			
No	17,716 (67.77)	24.04	Ref.
Yes	8426 (32.23)	25.51	<0.001
Age			
60–69	16,604 (63.43)	25.38	Ref.
70–79	7333 (28.02)	23.66	<0.001
80+	2238 (8.55)	20.98	<0.001
Education			
No	13,047 (49.85)	20.85	Ref.
Primary	5024 (19.19)	25.67	<0.001
Secondary/ higher	8104 (30.96)	29.98	<0.001
Sex			
Male	13,126 (50.15)	26.61	Ref.
Female	13,049 (49.85)	22.53	<0.001
Marital status			
Currently in union	17,306 (66.12)	25.66	Ref.
Widowed	8197 (31.32)	22.28	<0.001
Not in union	672 (2.57)	25.02	0.037
Living arrangement			
Alone	1293 (4.94)	22.68	Ref.
With spouse	5291 (20.21)	25.30	<0.001
With spouse and children	11,823 (45.17)	25.82	<0.001
Others	7768 (29.68)	22.52	0.418
Working status			
Never	7127 (27.23)	23.16	Ref.
Not	8745 (33.41)	23.76	<0.001
Yes	7857 (30.02)	25.15	<0.001
Retired	2446 (9.34)	29.87	<0.001
Social participation			
No	10,835 (41.70)	22.46	Ref.
Yes	15,149 (58.30)	25.30	<0.001
Tobacco use			
No	16,011 (61.25)	24.64	Ref.
Yes	10,129 (38.75)	24.51	0.126
Alcohol consumption			
No	21,683 (82.92)	24.43	Ref.
Yes	4465 (17.08)	25.36	<0.001
SRH			
Very good	898 (3.43)	27.10	Ref.

(continued)

Table 2 (continued)

Background variables	Number (%)[a]	Mean cognition score (0–43)[b]	*p*-value[c]
Good	8054 (30.79)	25.42	<0.001
Fair	11,559 (44.18)	24.42	<0.001
Poor	5008 (19.14)	23.45	<0.001
Very poor	642 (2.45)	22.15	<0.001
ADL difficulty			
0	21,175 (80.91)	25.00	Ref.
1	2225 (8.50)	23.88	<0.001
2	1151 (4.40)	22.87	<0.001
3+	1620 (6.19)	21.12	<0.001
IADL difficulty			
0	15,332 (58.62)	26.00	Ref.
1	2924 (11.18)	24.43	<0.001
2	2051 (7.84)	23.46	<0.001
3+	5849 (22.36)	21.27	<0.001
Wealth quintile			
Poorest	5100 (19.48)	23.08	Ref.
Poorer	5267 (20.12)	23.88	<0.001
Middle	5398 (20.62)	24.52	<0.001
Richer	5267 (20.12)	25.14	<0.001
Richest	5143 (19.65)	26.35	<0.001
Religion			
Hindu	19,258 (73.57)	24.60	Ref.
Muslim	3086 (11.79)	24.14	<0.001
Others	3831 (14.64)	24.42	0.131
Caste			
SC/ST	8145 (31.12)	22.96	Ref.
OBC	10,023 (38.29)	24.82	<0.001
Others	8007 (30.59)	26.01	<0.001
Place of residence			
Urban	9285 (35.47)	26.98	Ref.
Rural	16,890 (64.53)	23.32	<0.001
Region			
North	4944 (18.89)	24.64	Ref.
Central	3724 (14.23)	23.78	<0.001
East	4784 (18.28)	24.21	<0.001
Northeast	3050 (11.65)	24.28	0.012
South	6412 (24.50)	25.52	<0.001
West	3261 (12.46)	24.51	0.314
Total	26,175	24.52 (SD = 6.70)	

Source: Author's calculations from LASI

[a]Data are unweighted

[b]Data are weighted, where 0 is worst and 43 is best cognition score

[c]*p*-value from simple linear regression

SRH self-rated health, *ADL* activities of daily living, *IADL* instrumental activities of daily living

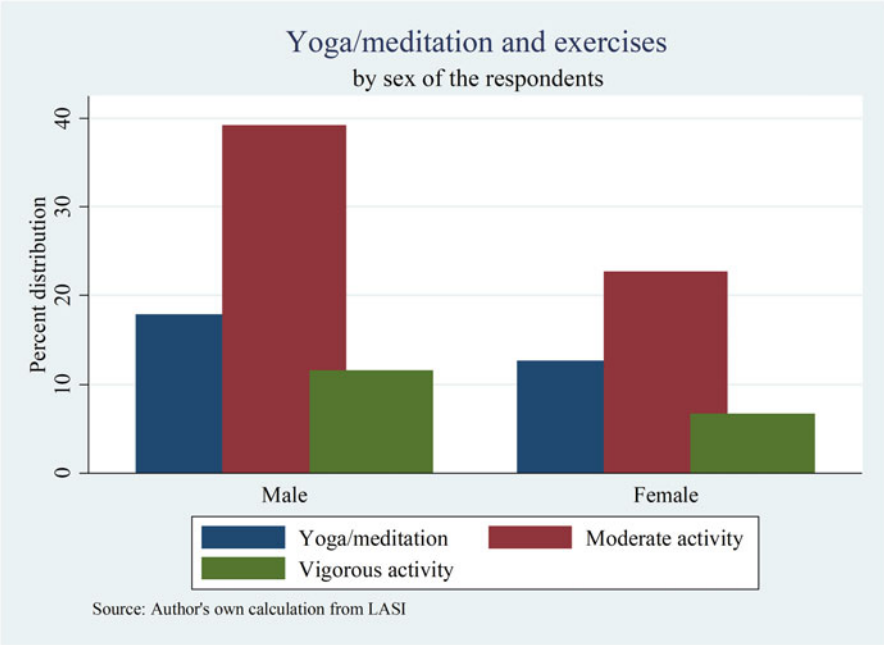

Fig. 1 Percentage distribution of older adults by activity status

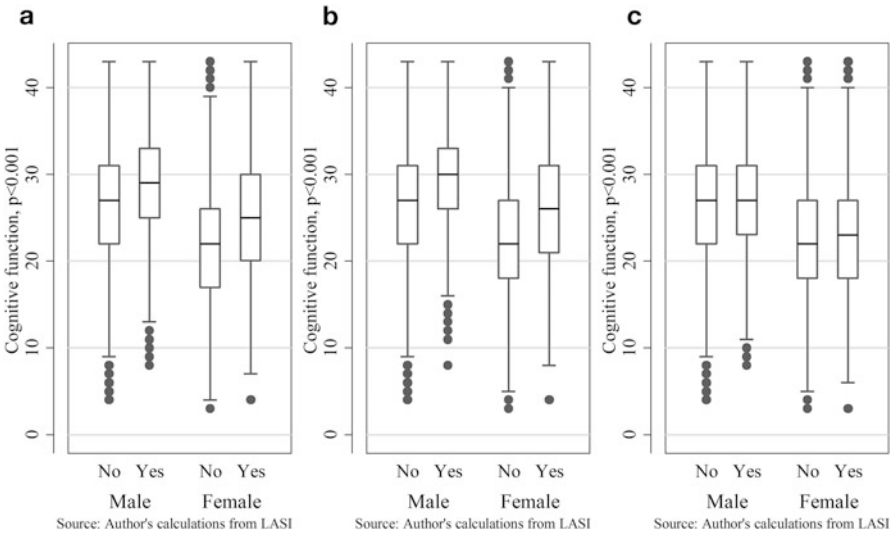

Fig. 2 (**a**) Bivariate association of cognitive function with yoga/meditation; (**b**): bivariate association of cognitive function with moderate physical activity; and (**c**): bivariate association of cognitive function with vigorous physical activity

4.4 Mean Cognition Score Among Older Adults

Overall, the mean cognition score of older respondents was 24.52 (SD = 6.70). The mean cognition score was higher among those who did yoga/ meditation (26.97), reported moderate physical activity (27.95) and vigorous physical activity (25.51). The mean cognition score among older men (26.61) was significantly higher than woman counterparts (22.53). The score decreased in the higher age groups and increased with advancing level of education among older adults. Retired older persons were having a greater mean cognitive score (29.87) compared to other categories of work status. Older individuals who were currently married (25.66), coresiding with spouse and children (25.82), and participating in social activities (25.30) were shown to have higher cognitive score than their counterparts. Higher cognitive score was seen among older adults who reported very good SRH (27.10), who were not having any difficulty performing ADL (25.00) or IADL (26.00), who fell in the richer and richest wealth quintile (26.35), and who were living in urban areas (26.98).

4.5 Multivariate Estimations of Cognitive Function Among Older Adults

Table 3 shows the results from the linear regression analyses, which present the unadjusted and adjusted estimates of older adults' cognitive functioning. The unadjusted coefficients demonstrate the individual effect of each predictor including yoga/meditation and moderate/vigorous physical activities, sociodemographic, economic, and health-related predictors. After controlling for all these variables, older adults who were practicing yoga/meditation [aCoef. = 0.56, $p < 0.001$], and those who reported moderate [aCoef. = 0.22, $p < 0.05$] and vigorous [aCoef. = 0.53, $p < 0.001$] physical activity, were significantly associated with better cognitive function compared to their respective counterparts.

Furthermore, increasing age was significantly associated with poor cognitive functioning [aCoef. = −0.11, $p < 0.001$], whereas, increasing education was associated with better cognitive functioning [aCoef. = 0.65, $p < 0.001$]. Older women had significantly poorer cognitive functioning [aCoef. = −4.12, $p < 0.001$] than older men. Older adults who were widowed [aCoef. = −0.80, $p < 0.05$] were associated with poorer cognitive functioning than older individuals who were currently in a marital union. In comparison to never worked older adults, currently working individuals have higher cognitive functioning [aCoef. = 0.27, $p < 0.01$], whereas individuals who participated in social activities were negatively correlated with cognitive functioning [aCoef. = 1.24, $p < 0.001$] compared to those who did not participate in such activities. The health-related indicators such as reporting very poor SRH [aCoef. = −1.38, $p < 0.001$]; having 3+ difficulty in performing ADL [aCoef. = −1.23, $p < 0.001$] and IADL [aCoef. = −1.34, $p < 0.001$] were associated with lower level of cognitive functioning. Older adults who belonged to richest wealth quintile were associated with higher level of

Table 3 Regression estimates of cognitive functioning by socioeconomic and health characteristics among older adults

Variables	Response	uCoef. (95% CI)	aCoef. (95% CI)	Standardized beta
Yoga/meditation	No	Ref.	Ref.	Ref.
	Yes	2.87*** (2.65–3.09)	0.56*** (0.39–0.73)	0.03
Moderate physical activity	No	Ref.	Ref.	Ref.
	Yes	3.82*** (3.56–4.09)	0.22* (0.01–0.44)	0.04
Vigorous physical activity	No	Ref.	Ref.	Ref.
	Yes	1.47*** (1.30–1.64)	0.53*** (0.38–0.67)	0.04
Age	In years	−0.19***(−0.20 to −0.18)	−0.11***(−0.12 to −0.10)	−0.11
Education	In years	0.86*** (0.84–0.87)	0.65*** (0.63–0.66)	0.46
Sex	Male	Ref.	Ref.	Ref.
	Female	−4.12***(−4.28 to −3.97)	−1.59***(−1.76 to −1.42)	−0.12
Marital status	Currently in union	Ref.	Ref.	Ref.
	Widowed	−3.51***(−3.68 to −3.34)	−0.80*(−1.51 to −0.09)	−0.06
	Not in union	−0.53*(−1.03 to −0.03)	−0.33 (−1.12–0.47)	−0.01
Living arrangement	Alone	Ref.	Ref.	Ref.
	With spouse	2.75*** (2.36–3.15)	−0.38 (−1.13–0.36)	−0.02
	With spouse and children	3.25*** (2.87–3.62)	−0.09 (−0.83–0.65)	−0.01
	Others	−0.16 (−0.54–0.22)	0.11 (−0.19–0.40)	0.01
Working status	Never	Ref.	Ref.	Ref.
	Not	0.51*** (0.31–0.71)	0.18* (0.00–0.35)	0.01
	Yes	2.00*** (1.80–2.21)	0.27** (0.07–0.47)	0.02
	Retired	6.73*** (6.44–7.03)	0.24 (−0.03–0.50)	0.01
Tobacco use	No	Ref.	Ref.	Ref.
	Yes	−0.12 (−0.29–0.04)	0.05 (−0.09–0.20)	0.00

(continued)

Table 3 (continued)

Variables	Response	uCoef. (95% CI)	aCoef. (95% CI)	Standardized beta
Alcohol consumption	No	Ref.	Ref.	Ref.
	Yes	0.94*** (0.72–1.15)	−0.36***(−0.55 to −0.18)	−0.02
Social participation	No	Ref.	Ref.	Ref.
	Yes	2.87*** (2.71–3.03)	1.24*** (1.11–1.36)	0.09
SRH	Very good	Ref.	Ref.	Ref.
	Good	−1.59***(−2.04 to −1.13)	0.02 (−0.32–0.36)	0.00
	Fair	−2.67***(−3.12 to −2.22)	−0.18 (−0.52–0.16)	−0.01
	Poor	−3.67***(−4.14 to −3.20)	−0.43*(−0.79 to −0.07)	−0.03
	Very poor	−5.20***(−5.87 to −4.53)	−1.38***(−1.89 to −0.86)	−0.03
ADL difficulty	0	Ref.	Ref.	Ref.
	1	−1.19***(−1.48 to −0.90)	−0.01 (−0.24–0.21)	−0.00
	2	−2.21***(−2.61 to −1.82)	−0.13 (−0.43–0.18)	−0.00
	3+	−4.19***(−4.52 to −3.85)	−1.23***(−1.51 to −0.95)	−0.04
IADL difficulty	0	Ref.	Ref.	Ref.
	1	−1.56***(−1.82 to −1.31)	−0.35***(−0.55 to −0.15)	−0.02
	2	−2.54***(−2.83 to −2.24)	−0.42***(−0.66 to −0.18)	−0.02
	3+	−4.89***(−5.09 to −4.70)	−1.34***(−1.52 to −1.16)	−0.08
Wealth quintile	Poorest	Ref.	Ref.	Ref.
	Poorer	0.82*** (0.57–1.07)	0.22* (0.03–0.42)	0.01
	Middle	1.50*** (1.25–1.75)	0.46*** (0.27–0.65)	0.03
	Richer	2.11*** (1.86–2.37)	0.72*** (0.52–0.92)	0.04
	Richest	3.36*** (3.11–3.62)	0.93*** (0.72–1.14)	0.06
Religion	Hindu	Ref.	Ref.	Ref.
	Muslim	−0.46***(−0.71 to −0.20)	−0.18 (−0.37–0.02)	−0.01
	Others	−0.18 (−0.41–0.05)	−0.14 (−0.34–0.06)	−0.01

(continued)

Table 3 (continued)

Variables	Response	uCoef. (95% CI)	aCoef. (95% CI)	Standardized beta
Caste	SC/ST	Ref.	Ref.	Ref.
	OBC	1.91*** (1.72–2.10)	0.94*** (0.79–1.10)	0.07
	Others	3.15*** (2.95–3.36)	0.77*** (0.59–0.94)	0.05
Place of residence	Urban	Ref.	Ref.	Ref.
	Rural	−3.79***(−3.95 to −3.62)	−1.40*** (1.26–1.54)	−0.10
Region	North	Ref.	Ref.	Ref.
	Central	−0.89***(−1.18 to −0.61)	0.23* (0.01–0.46)	0.01
	East	−0.49***(−0.76 to −0.23)	0.38*** (0.17–0.58)	0.02
	Northeast	−0.39*(−0.69 to −0.09)	0.14 (−0.10–0.39)	0.01
	West	0.83*** (0.58–1.08)	0.88*** (0.68–1.08)	0.06
	South	−0.15 (−0.45–0.14)	−0.85***(−1.07 to −0.62)	−0.04
Constant			28.28*** (27.18–29.37)	
Observations			25,927	
R2			0.46	

Source: Author's calculations from LASI
uCoef and aCoef are unadjusted and adjusted raw (nonstandardized) coefficients
CI confidence interval, *Ref.* reference category, *SRH* self-rated health, *ADL* activities of daily living, *IADL* instrumental activities of daily living

cognitive functioning [aCoef. = 0.93, $p < 0.001$] in comparison to older individuals from poorest quintile.

5 Summary and Discussion

The current study using the baseline survey data of LASI, explored the cognitive score among older adults and the association of yoga/meditation and physical exercises (both moderate and vigorous) with late-life cognitive functioning. A lower cognitive score was observed among women and oldest old (80+) categories which is in line with previous studies in India and other countries suggesting that female gender and increasing age are significant risk factors of cognitive dysfunction (Lei et al., 2012; Onur & Velamuri, 2016; Singh et al., 2018; Yount, 2008). The lower levels of cognitive function among older women remained significant in

multivariate analysis after controlling for several sociodemographic and health-related variables. This suggests that female gender is an independent risk factor for cognitive impairment among older adults which calls for special attention from researchers and policymakers.

Gender differences in the prevalence of yoga/meditation and types of physical activity are observed in the current study and showed that women engage lesser in these activities compared to men. This must be interpreted in light of the fact that the household works such as cleaning house, washing clothes, etc. in which women are more involved are also included in self-report of moderate activities considered in this study. The lower levels of participation in physical activities by women than men may be linked to the prevailing sociocultural norms and barriers in the country that constrain women's mobility and limit their participation in physical activity (Adlakha & Parra, 2020), and the motivation to engage in physical activity comes under strong social influences in most of the cases. Therefore, public health practitioners must develop initiatives to address the gender-based barriers in terms of increasing the physical activity among women, especially in the late life. The motivators that guide physical activity in males tend to be more intrinsic like improving health and being more competitive; they tend to be a combination of extrinsic and intrinsic factors such as emotional support and positive body image (Rosenfeld, 2017). Therefore, further studies in this area may reveal complex interactions between genetic background and environmental factors that ultimately affect motivation to engage in physical activity among males and females differentially.

Another important finding of the current study is that yoga/meditation was significantly associated with better cognitive function among older adults. Consistently, multiple studies in various countries on mind-body practices including yoga, Tai chi, and Qigong have shown a physical component with higher cognitive demand and beneficial effects on cognitive health in patients and nonpatients (Bhattacharyya et al., 2021b; Tao et al., 2019; Wang et al., 2018; Wu et al., 2019). A systematic review of randomized controlled trials suggested that yoga-based interventions are associated with improvements in cognition in healthy older adults (Hoy et al., 2021). The current finding is also consistent with earlier evidence on several types of mindfulness activities including yoga and meditation that have beneficial effects on cognitive functions among older adults (Hoy et al., 2021; Ji & Yu, 2018; Thomas & Venkatesh, 2017). An earlier study revealed that yoga may ameliorate the symptoms of depression and thereby reduce cognitive decline and potentially prevent dementia (Mathersul & Rosenbaum, 2016). Similarly, a Chinese form of a multicomponent practice known as Tai Chu Chuan, which is characterized by its physical, social, and environmental domains of movements, is also found to have cognitive health benefits (Chang et al., 2010). Yoga-based exercise includes physical components that are important for healthy aging, such as balance and flexibility.

Furthermore, both moderate and vigorous physical activities in this study were associated with better cognitive score among older adults. However, in comparison to types of physical activities, yoga/meditation showed stronger association with

cognitive function after adjusting for a large number of confounders. In line with this, exercise interventions that have higher cognitive demands are shown to be more effective for enhancing cognitive abilities among older persons (Netz, 2019). The comparatively greater magnitude of the yoga/meditation and cognition association in this study also supports the previous finding on the association of yoga with fewer injuries in comparison to other activities (Welford et al., 2022) and may be considered especially suitable for older adults. Moreover, the sex differences in exercise efficacy which may be related to sex differences in neuroplasticity and physiological responses to exercise are documented in previous studies (Barha & Liu-Ambrose, 2018). Concordantly, the cognitive score associated with any type of activity was observed lower among older women than men in the current study. This suggests that the types of activities considered in this study could be included in gender-neutral health-promotion programs as to enhance cognitive abilities.

The mechanisms underlying the associations of physical activities and cognitive health are poorly understood. Previous studies suggested some hypotheses that relate to biological aspects as follows: (1) Physical activity may sustain cerebral blood flow and may improve nutrient supply and aerobic capacity (Bherer et al., 2013; Eisenstein et al., 2021); (2) physical activity may facilitate neurotransmitter metabolism and serve neuro-protective functions (Van Gelder et al., 2004); and (3) physical activity may trigger molecular and cellular changes that support and maintain brain plasticity (Cotman & Berchtold, 2002). Another explanation could be that physical activity reduces the risk of chronic conditions including cardiovascular diseases that are associated with cognitive impairments (Eggermont et al., 2009; Loprinzi et al., 2017; Rabin et al., 2019). Given that the intensity of physical activity has been shown to be an important factor in determining cognitive improvements following other exercise interventions, we propose that the intensity of yoga-based physical activity should be considered in the design and reporting of future studies. Indeed, different styles of yoga differ in their intensity level and the relationship between heart rate and oxygen consumption in yoga-based exercise is nonlinear (compared to the linear relationship in aerobic exercise), which suggests there is a need to create a standard for reporting intensity levels from yoga interventions.

6 Limitations of the Study

Since this is a cross-sectional study, the possibility of reverse causality cannot be ruled out. Hence, care must be taken while making the causal inferences about the relationship between yoga/meditation and physical exercise of aged people and their cognitive functioning. It may be the case that a reverse causation can be inferred where older adults who are cognitively healthy are more engaged in meditation. Also, lower levels of cognition may lead older people to disengage themselves from various physical activities, which may make it seem as if those involved in physical activities are more cognitively healthy than their counterparts. The current finding regarding yoga is also limited by the question which does not imply the type of specific yoga/meditation activities practiced which limits the understanding about

the connection between the type of mindfulness activities practiced and the cognitive benefits gained. Further, the self-report nature of key explanatory variables may be subject to reporting bias and the dichotomization may be associated with some loss of information, and thus, the results should be interpreted in light of this fact. Finally, early-life risks such as childhood malnutrition, lack of education, and mid- and late-life risks such as unemployment and poor household financial status, all may exert their influence on late-life cognitive health differently for men and women, and future studies are warranted in this direction.

7 Implications and Concluding Remarks

The results of the present study suggest that females in their older age are physically less active compared to older males. Given the significant sex differences in reporting engagement in yoga/meditation and physical exercises, policy makers must design sex-specific programs to encourage such activities among older men and women alike. For instance, the structure of an exercise program for women may emphasize the social aspects in terms of meeting others and providing a supportive environment whereas for men it can be more competitively driven and promote the health benefits of participating in such activities.

The current study further provides evidence of the importance of involving in physical exercises and yoga/meditation in order to enhance the cognitive functions in community-dwelling older adults. It would be crucial for policymakers and practitioners to advocate such health-promotional programs that help maintain the cognitive abilities of older individuals and ensure active aging. Mindfulness activities combined with physical activities may be considered as a holistic non-pharmacological approach to health and well-being that could help address the complex health-related issues, especially cognitive impairment in the later years of life. The sex differences suggest that older women compared to men are less engaging in yoga/meditation and physical activities and are resultantly scoring lower on cognition.

However, interventional studies should be conducted on specific vulnerable populations and move beyond the "one-size-fits-all" approach in the observed physical activity-cognition associations. Findings from the current population-based cross-sectional study also highlight that future studies with longitudinal design should be conducted to explore the underlying mechanisms in the observed associations. Further investigation of the role of yoga and related activities in self-care and improving mental health could inform health-related challenges faced by aging population in many countries.

Declarations Ethics approval and consent to participate: The agencies that conducted the field survey for the data collection have collected prior informed consent from the respondents. The Indian Council of Medical Research (ICMR) and other partner institutions extended the necessary guidance and ethical approval for conducting the LASI.

Availability of data and materials: The study utilizes a secondary source of data that is freely available in the public domain through a request from https://iipsindia.ac.in/sites/default/files/LASI_DataRequestForm_0.pdf

The administrative permission was obtained from the International Institute for Population Sciences, Mumbai, for using the data for the current analysis.

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