Article

Association Between Cognitive Performance and Nutritional Status: Analysis From LASI-DAD

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Abstract

Malnutrition in low- and middle-income countries causes cognitive decline and other health problems. Harmonized Diagnostic Assessment of Dementia for Longitudinal Aging Study in India (LASI DAD) is an extensive study on late-life cognition and dementia. This study examines the link between nutrition and cognitive abilities in older adults using data from the LASI DAD. We conducted descriptive statistics on nutritional parameters (body-mass index, waist-hip ratio, and Mini-Nutritional Assessment), cognitive functions, and socio-demographic variables in 2,892 adults aged ≥60 years. Cognitive domains assessed included delayed recall, orientation, language, executive function, abstract reasoning, and attention. Cognitive impairment was defined as impaired performance in two or more domains. Mean age was 69.3 ± 7.1 years, 52.9% were female, and 57.5% were illiterate. Low body-mass index (adjusted OR: 1.88, $p < .001$), at risk of malnutrition (adjusted OR: 1.89, $p < .001$) and malnourished (adjusted OR: 2.86, $p < .001$) on Mini-Nutritional Assessment were associated with the presence of cognitive impairment. Better cognitive performance was associated with increased body mass index (adjusted OR: 0.74, *p*-.03), hemoglobin (adjusted OR: 0.91, *p*-.006), and serum albumin (adjusted OR: 0.38, $p < .001$). This study shows that nutritional status assessed by anthropometric measures and blood markers is strongly linked to cognitive performance in older adults.

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Introduction

Due to aging of the global population and increased life expectancy, cognitive decline is projected to become a serious human, social, and economic burden. Major neurocognitive disorder (MNCD) is a syndrome characterized by a significant deterioration of cognitive domains compared to previous performance levels. It may also be associated with changes in emotional behavior and difficulties at the functional level (Sousa et al., 2020). Recent studies have reported a higher prevalence of malnutrition in older adults with cognitive impairment (mild cognitive impairment and MNCD).

Malnutrition is a significant problem in low-middle-income countries (LMICs) like India. It leads to a wide range of health problems resulting in poor quality of life in older adults, mostly related to an elevated risk of morbidity, and mortality (Izawa et al., 2006; Kagansky et al., 2005; Vetta et al., 1999; Visvanathan, 2003). Moreover, poor nutritional status is associated with several geriatric syndromes, including cognitive impairment, a significant cause of disability in older adults (Orsitto et al., 2005). Despite the prevailing status of malnourishment in older adults, it is often unrecognized, and undertreated. As part of geriatric assessment, early detection of malnutrition remains an essential strategy for improving the care of older adults. Anthropometric measurements like; body mass index (BMI), mid-arm circumference (MAC), calf circumference (CC), and waist-hip ratio (WHR) along with Mini Nutritional Assessment (MNA) are often used to evaluate the nutritional status (Guigoz et al., 2002; Vellas et al., 1999). However, in most studies, BMI was used to measure nutritional status.

Hemoglobin level (Mitrache et al., 2001), serum albumin-globulin ratio (Chen et al., 2022), and serum creatinine (Corsonello et al., 2020) are also blood markers of an individual's nutritional status. Few small studies, limited to a single geographic distribution, have reported the association between nutritional status and cognition (Maity et al., 2019; Naik & Nirgude, 2020). Studies on the utilization of anthropometric measurements, MNA, and blood-based indicators of malnutrition, and cognitive function are not available from the Indian subcontinent. We intend to bridge this gap by using rich data from a nationally representative sample of Harmonized Diagnostic Assessment of Dementia for LASI (LASI DAD).

Longitudinal Ageing Study in India (LASI) is a pioneering and nationally representative study of the country's aging population, focusing on essential domains such as physical and cognitive health and economic, and social well-being (Banerjee et al., 2020). Harmonized Diagnostic Assessment of Dementia for LASI (LASI DAD) is an extensive study on late-life cognition and dementia, drawing a sub-sample of 60+ individuals from the LASI study. It also collects rich epidemiological data regarding aging issues through a detailed geriatric assessment (Lee & Dey, 2020). The present study utilizes the LASI DAD data to investigate the association between nutritional status (anthropometry and nutritional biomarkers) and cognitive impairment.

Methodology

General Study Details

We utilized data from the first wave of LASI DAD, including 4,096 participants. The relevant Institutional Review Boards approved the study, and informed consent was obtained from participants. For this analysis, we included 2,892 community-dwelling older adults with complete data on all nutritional parameters. The data was collected during the fieldwork of the LASI DAD between October 2017 and March 2020. Methodological considerations of LASI DAD have been presented previously (Banerjee et al., 2020; Lee et al., 2019). The collected data includes socio-demographic variables, health, economic and cognitive status from rural and urban areas across the 18 states in India. As part of LASI DAD, venous blood samples were collected by trained phlebotomists. Every step was monitored for optimum temperature maintenance and time taken for sample transportation. The blood-based complete assays were performed.

Variables

For socio-demographic variables, we have taken (1) age, categorized as 60 to 70 and more than 70 years, (2) gender, (3) education, subdivided into no formal education and literate, and (4) habitation, as rural and urban.

Assessment of Nutritional Status. Anthropometric measurements were taken using standard instruments; a stadiometer was used for height and a weighing scale for weight to determine the BMI of the individuals. BMI was categorized as undernutrition (<18.5), normal (18.5–24.9), over-nutrition (25–30), and obese (≥30) (*A healthy lifestyle—WHO recommendations*, n.d.). A measuring tape was used to measure waist and hip circumference for WHR by trained research nurses and field workers. The waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest. Similarly, hip circumference was measured around the widest portion of the buttocks with the tape parallel to the floor (Başıbüyük et al., 2021). According to World Health Organization, abdominal obesity is a WHR above 0.90

and 0.85 for males and females, respectively (*Waist circumference and waist-hip ratio: Report of a WHO expert consultation*, n.d.). MNA is an internationally validated, commonly used tool in older adults to assess and screen nutritional status. The MNA scores are used to classify patients as well-nourished (score 24–30), at risk for malnutrition (17–23.5), and malnourished (<17) (Vellas et al., 1999).

Blood Biomarkers. The LASI DAD team trained the phlebotomist to collect fasting venous blood. The proper temperature was maintained at the sample collection site and immediately transferred to the nearest regional center for processing and storage. We have included hemoglobin, serum albumin, globulin, and creatinine.

Assessment of Cognition. To evaluate cognitive domains, 16 tests were selected for LASI-DAD (Banerjee et al., 2020). We included six tests, which were delayed recall of "Word learning and recall," orientation, language, clock drawing test, Raven's test, and digit span forward, and backward. The domains assessed were delayed recall, orientation, language, executive function, abstract reasoning, and attention.

Delayed Recall: We took the Delayed Recall Test of Word Learning and Recall Test to see the individual's memory function. The test gave the respondent 10 high imaginary words for 2 s each. The respondents were asked to recall the 10-word list after a delay where other survey questions were asked and answered. Respondents were given 2 min to recall as many words as possible. This test assessed the memory function of older adults.

Orientation: The 10 questions on orientation to time and location, which were a part of the mental status examination, were included to examine orientation. For time, participants were enquired regarding month, year, week, season, and date. And for location: the name of the state, city, floor, name of the place, and address were asked.

Language: To assess the language domain, the following tests, which are a part of the mental status examination, were administered: object naming, repeat phrase, following command/read command, writing, or saying a sentence.

Clock Drawing Test: This test helped in the evaluation of the visuospatial skills and executive functions of the respondents. It is based on three components (1) whether the respondent drew a closed circle, (2) whether the respondent correctly placed and ordered the clock numbers on the circle, and (3) whether the respondent drew the two clock hands.

Raven's Test: Raven's test helped assess the respondent's executive functions. Each question presented a geometric picture with a small section that appears to have been cut out. The respondent was shown a set of smaller images that fit the missing piece and was asked to identify the correct one to complete the pattern.

Digit Span Forward and Backward: In this test, a list of random numbers of single digits were read aloud at one word per second. The respondent was asked to repeat them in the same order as they were given. At the end of the sequence, they were asked to recall the items in reverse of the presented order. The LASI-DAD database had provided the data as normal and impaired.

Participants who were literate and illiterate, as well as those between the ages of 60 to 70 and >70, showed statistically significant differences in their scores. The "cutoff" scores for each of the aforementioned groups were determined using the lowest quartile. For delayed word recall, the cutoff score for literate individuals in the 60 to 70 age range was 5, while it was 3 for illiterate participants in the same age range. The scores for educated and illiterate participants among elderly persons (>70) were 3 and 2, respectively. Further, we defined cognitive impairment as impaired performance in two or more cognitive domains.

Statistical Analysis. The analyses were performed using STATA version 14 (StataCorp, 2015) while the forest plot was prepared using GraphPad Prism version 9.2.0 (RRID:SCR_002798). Categorical variables are expressed as frequencies and percentages; continuous variables are represented as mean and standard deviation (SD). The *t*-test or Wilcoxon rank sum test compared continuous variables between two groups, while categorical variables were compared using the Chi-squared test.

We used survey-weighted logistic regression to estimate the associations between cognitive impairment and nutritional parameters. We evaluated three sets of models: Model 1 did not adjust for confounders, Model 2 adjusted for age category (60–70 & ≥70 years) and sex, and Model 3 additionally adjusted for literacy, habitat (urban, rural), and depression (defined as CESD-10 score ≥10). The results are represented as odds ratio (OR) with a 95% confidence interval (CI). *p*-Value less than .05 were considered statistically significant.

Results

The study population's mean age was 69.3 ± 7.1 years, and 1,531 (52.9%) were female (Table 1). Over half (1,663, 57.5%) were illiterate, and most were rural residents (1,875, 64.8%). In terms of the cognitive domains, executive function, abstract reasoning, and attention were all affected in 1,590 (54.9%), 842 (29.1%), and 1,731 (59.9%), respectively. Delayed recall was also impaired in 875 (30.3%), orientation in 517 (17.9%), and language in 482 (16.7%). Among the study population, 1,745 (60.3%) had impairment in two or more cognitive domains. The descriptive statistics of each domain score is provided in Supplemental Table 1.

Table 1. Baseline Characteristics of the Study Population.

Variables	Frequency (*n* = 2,892)	Unweighted percentage (%)	Weighted percentage (%)
Age			
60–70 years	1,822	63.0	64.6
≥71 years	1,070	37.0	35.4
Sex			
Male	1,361	47.1	49.9
Female	1,531	52.9	50.1
Education			
Illiterate	1,663	57.5	58.2
Literate	1,229	42.5	41.8
Habitat			
Urban	1,017	35.2	47.3
Rural	1,875	64.8	52.7
Depression	1,387	50.1	48.9
Body mass index (kg/m^2)			
<18.5	590	21.9	19.9
18.5–24.9	1,347	49.9	50.5
25.0–29.9	539	20.0	20.5
≥30.0	221	8.2	9.1
Waist-hip ratio			
Normal	489	18.4	17.7
High	2,173	81.6	82.3
Mini-nutritional assessment			
Normal	437	16.9	17.1
At risk of malnutrition	1,748	67.4	69.1
Malnourished	408	15.7	13.8
Test of cognition (impaired)			
Delayed recall	875	30.3	28.1
Orientation	517	17.9	16.4
Language	482	16.7	15.9
Executive function	1,590	54.9	52.8
Abstract reasoning	842	29.1	27.2
Attention	1,731	59.9	59.1
Total cognition	1,745	60.3	57.8

Association With Nutritional Parameters

Participants with cognitive impairment had a lower BMI (21.7 vs. 23.9, *p*-value .001) than those without. Cognitive impairment was more common among participants with low waist-hip ratios (326, 66.7%, *p*-value .001). Older people with cognitive impairment had a lower MNA score (19.6 vs. 21.3, *p*-value < .001), and nearly three-fourths (74.3%) of malnourished had cognitive impairment. The cognitive impairment group also had a lower hemoglobin level (12.4 vs. 13.0, *p*-value < .001) and lower albumin-globulin ratio (1.3 vs. 1.3, *p*-value < .001) (Table 2).

Additional survey-weight univariate regression analysis (Table 3, Model 1) showed that cognitive impairment was associated with low BMI, normal WHR, poor MNA, low hemoglobin, albumin, and low AG ratio. When these variables were adjusted for covariates such as age, sex, literacy, habitat, and depression (model 3), the presence of low BMI (OR: 1.88, 95% CI [1.38, 2.57], *p*-value < .001), at risk of malnutrition (OR: 1.89, 95% CI [1.39, 2.56], *p*-value < .001), malnourishment (OR: 2.86, 95% CI [1.85, 4.44], *p*-value < .001) were significantly associated with presence of cognitive impairment. Whereas a BMI between 25 and 29.9 (OR: 0.75, 95% CI [0.56, 0.97], *p*-value: .03), BMI ≥ 30 (OR: 0.62, 95% CI [0.41, 0.94]. *p*-value: .023), higher hemoglobin (OR: .92, 95% CI [0.86, 0.98], *p*-value: .006), and higher serum albumin (OR: 0.38, 95% CI [0.26, 0.55], *p*-value < .001) had lower risk of cognitive impairment.

Domain Wise Association

A multivariate analysis to identify an association between significant nutritional parameters and individual domains of cognition is shown in Figure 1. Impaired delayed recall, orientation, and attention were linked to low BMI. Flawed delayed recall, executive function, abstract reasoning, and attention were all associated with MNA impairment. Higher hemoglobin was associated with better executive function and abstract

Table 2. Association Between Cognition and Nutritional Parameters.

Variables	Intact cognition (n = 1,147)	Impaired cognition (n = 1,745)	p-Value
Age			
Mean ± *SD*	68.29 ± 6.35	70.36 ± 7.92	<.001
60–70	779 (42.8)	1,043 (57.2)	<.001
>71	368 (34.4)	702 (65.6)	
Sex			
Male	652 (47.9)	709 (52.1)	<.001
Female	495 (32.3)	1,036 (67.7)	
Education			
Years of education	6 (0–10)	0 (0–4)	<.001
Literate	669 (54.4)	560 (45.6)	<.001
Illiterate	478 (28.7)	1,185 (71.3)	
Habitat			
Urban	520 (51.1)	497 (48.9)	<.001
Rural	627 (33.4)	1,248 (66.6)	
BMI (kg/m^2)			
Mean ± *SD*	23.86 ± 5.11	21.66 ± 4.76	<.001
<18.5	153 (25.9)	437 (74.1)	<.001
18.5–24.9	536 (39.8)	811 (60.2)	
25.0–29.9	280 (51.9)	259 (48.1)	
≥30.0	124 (56.1)	97 (43.9)	
Waist-hip ratio			
Mean ± *SD*	0.95 ± 0.08	0.93 ± 0.09	<.001
Normal	163 (33.3)	326 (66.7)	<.001
High	915 (42.1)	1,258 (57.9)	
Mini-nutritional assessment			
Mean ± *SD*	21.32 ± 3.29	19.59 ± 3.42	<.001
Normal	276 (63.2)	161 (36.8)	<.001
At risk of malnutrition	693 (39.6)	1,055 (60.4)	
Malnourished	105 (25.7)	303 (74.3)	
Hemoglobin			
Mean ± *SD*	13.04 ± 1.80	12.44 ± 1.94	<.001
Albumin			
Mean ± *SD*	4.19 ± 0.29	4.10 ± 0.35	<.001
Globulin			
Mean ± *SD*	3.27 ± 0.47	3.29 + 0.51	.182
Albumin-globulin ratio			
Mean ± *SD*	1.31 + 0.21	1.27 ± 0.22	<.001
Creatinine			
Mean ± *SD*	0.91 + 0.51	0.87 ± 0.39	.038

reasoning performance, whereas higher albumin correlated with improved performance in orientation, language, executive function, and attention.

Discussion

The main goal of the current study was to investigate the relationship between the nutritional status and cognitive performance of individuals ≥60 years. This study revealed a link between poor nutritional status (low MNA score, low BMI, low hemoglobin, and albumin) and poor cognitive function. According to this, undernutrition may be a factor in cognitive decline and subsequent disability. In fact, malnutrition leads to cognitive decline, further increasing the risk of malnourishment, forming a vicious cycle (Bell et al., 2015; Correia et al., 2014).

As part of geriatric assessment, nutritional status assessment and its management could be essential to preventing cognitive decline in community-dwelling older adults. We have included tests of six domains that define the cognitive functions of an individual. Further, we have described the presence of impaired cognition if the person has performed poorly in two or more domains. Compared to people without cognitive impairment, people with cognitive impairment had a higher mean age and a higher percentage of females (67.7%) than males. Our findings are consistent with a study (Gur & Gur, 2002) that found a reduction in cognitive test performance with aging and also noted a gender disparity.

Table 3. Univariate and Multivariate Logistic Regression Analysis.

Variables	Model 1 OR [95% CI]	Model 2 OR [95% CI]	Model 3 OR [95% CI]
BMI			
18.5–24.9	1 (ref)	1 (ref)	1 (ref)
<18.5	2.38 [1.79, 3.15] *	2.41 [1.80, 3.23]*	1.88 [1.38, 2.57]*
25.0–29.9	0.67 [0.52, 0.88] **	0.62 [0.47, 0.81]**	0.75 [0.56, 0.97]**
≥30.0	0.58 [0.39, 0.84]*	0.45 [0.31, 0.66]*	0.62 [0.41, 0.93]**
Waist-hip ratio			
Normal	1 (ref)	1 (ref)	1 (ref)
High	0.66 [0.50, 0.87] **	0.66 [0.49, 0.87]**	0.82 [0.60, 1.12]
Mini-nutritional assessment			
Normal	1 (ref)	1 (ref)	1 (ref)
At risk of malnutrition	2.62 [1.98, 3.47] *	2.63 [1.97, 3.49]*	1.89 [1.39, 2.56]*
Malnourished	5.85 [4.03, 8.49] *	5.28 [3.58, 7.78]*	2.86 [1.85, 4.44]*
Hemoglobin	0.83 [0.78, 0.88] *	0.89 [0.84, 0.94]*	0.92 [0.86, 0.98]**
Albumin	0.33 [0.23, 0.47] *	0.34 [0.24, 0.49]*	0.38 [0.26, 0.55]*
Globulin	1.14 [0.93, 1.39]	1.05 [0.86, 1.28]	0.93 [0.75, 1.15]
Albumin-globulin ratio	0.42 [0.26, 0.69]**	0.52 [0.32, 0.84]**	0.70 [0.43, 1.14]
Creatinine	0.79 [0.62, 1.02]	0.95 [0.76, 1.18]	1.00 [0.81, 1.24]

Model 1: unadjusted
Model 2: adjusted for age category (60–70 & ≥71) and sex.
Model 3: adjusted for age category (60–70 & ≥71), sex, literacy, habitat, and depression

*p-value < .001. **p-value < .05.

Educational status is generally a predictor of the individual's cognitive status (Bajpai et al., 2022). Studies have also demonstrated that cognitive abilities are associated with longer educational attainment duration. Similar to previous studies, we found an association between education and cognitive performance (Lövdén et al., 2020). Many participants with impaired cognition resided in rural areas (66.6%, $p < .001$). Our findings aligned with the earlier study, which showed that older adults living in rural areas had poor cognitive functioning than those residing in urban areas (Wilson et al., 2019).

When examining the relationship between body composition measurements and cognitive capabilities, prior research did not account for assessments of body fat and muscle mass (Saenz et al., 2018; Siparsky et al., 2014; Stewart et al., 2005). We used anthropometric measurements (BMI and WHR) as a marker of nutritional status. We found a significant association of BMI with cognitive function. Participants with low BMI had greater odds of having impaired cognitive function (adjusted OR: 1.88, $p < .001$). Participants with higher BMI (25–29.9 and ≥30 kg/m^2) had a lower prevalence of cognitive impairment. According to earlier research, those who are underweight, overweight, or obese are more prone than people with a normal BMI to experience cognitive deficits (Beydoun et al., 2008; Hallit et al., 2020; Luchsinger et al., 2007). Results on cross-sectional associations between BMI and cognitive impairment are consistent with findings from other LMIC studies (Concha-Cisternas et al., 2019).

Anthropometry is a non-invasive, affordable, portable and simple-to-use tool that can be used instead of more intrusive methods to screen for malnutrition in community-dwelling older persons. WHR is one of the predictors of central obesity. In the univariate analysis, we observed a significant relation between WHR and cognition (OR: 0.66, p-value: .003). When confounding factors were taken into account, WHR and cognitive impairment were not significantly associated. Previous studies have reported that normal WHR and higher MNA scores are related to better cognitive functions (Assis et al., 2020; Senger et al., 2019). In another study, WHR in women was negatively associated with global cognitive functions (de Rouvray et al., 2014). MNA scores were found to be related to overall cognitive function. The odds of impaired cognition were higher among participants at risk of malnutrition (adjusted OR-1.89, $p < .001$) and participants with malnutrition (adjusted OR-2.86, $p < .001$). Our findings are consistent with previous studies, which found a significant association between nutritional status defined by MNA and cognitive impairment (Feng et al., 2022; Hai et al., 2017).

Evidence suggests a link between anemia and frailty, which can result in several adverse effects like decreased muscle strength and cognitive deterioration (Llewellyn et al., 2010). We also reported an association between hemoglobin level and cognition in an ethnically diverse population. We found that individuals with poor cognitive functions had lower hemoglobin levels (12.5vs. 13, adjusted OR- 0.92, p-value: .006). Similar to previous studies, we found a significant association between serum albumin level and cognitive impairment (Dodel et al., 2013; Kim et al., 2006).

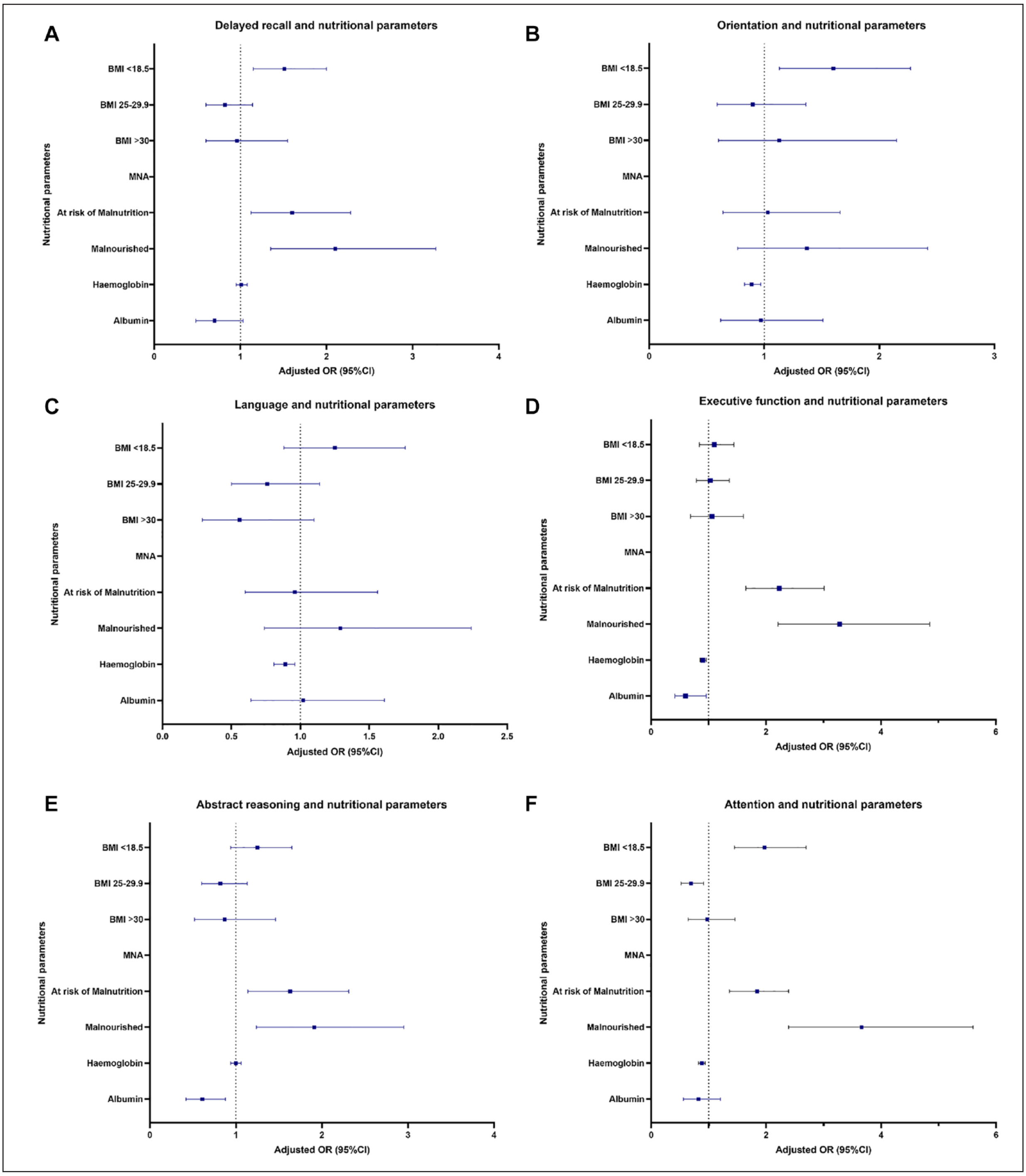

Figure 1. Results of multivariate analysis of nutritional parameters with delayed recall (a), orientation (b), language (c), executive function (d), abstract reasoning (e), and attention (f).

Strengths and Limitations

There are several limitations of our study. The use of only the first wave of LASI DAD makes this a cross-sectional study. We can only report associations since we cannot determine the direction of causality. We cannot determine how dietary and cognitive state change over time. The strengths of our study include a large, nationally representative sample, high-quality data from LASI-DAD, and the use of six distinct cognitive domains instead of a single screening tool such as mental status examination. The availability of social and economic data enables the correction of confounding factors that may affect dietary and cognitive performance.

Conclusion

The study provides evidence that nutritional status evaluated using BMI and MNA and biochemical blood markers are significantly associated with the cognitive performance of community-dwelling Indian older adults. Further, longitudinal studies are required to assess causation. In LMICs such as India, using anthropometric measurement as part of geriatric assessment could assist in identifying at-risk individuals and properly designing nutrition programs with extended follow-ups.

Declaration of Conflicting Interest

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Supplemental Material

Supplemental material for this article is available online.

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