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The impact of healthy lifestyles on cognitive function in community-dwelling older adults: A cross-sectional study in Shanghai, China

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Abstract: Recent literature has demonstrated the link between lifestyle behavior factors and cognitive function, yet most evidence comes from Western populations. This study examined the associations between multiple healthy lifestyle factors and cognitive function among community-dwelling older adults in Shanghai, China. This cross-sectional study included 942 residents aged ≥ 60 years in Pudong District, Shanghai, China, who participated in China's national free physical examination program from July to September 2024. Cognitive function and cognitive impairment status were assessed by Mini-Mental State Examination (MMSE). Five healthy lifestyle factors were considered: never smoking, healthy body mass index, regular physical activity, light-to-moderate alcohol drinking and optimal night sleep duration. A composite healthy lifestyle score (0–5) was calculated. Results showed that regular physical activity and optimal night sleep duration were positively correlated with a MMSE score [$\beta = 0.21$ (95% confidence interval (CI): 0.09–0.34), $p = 0.001$; $\beta = 0.15$ (95% CI: 0.03–0.27), $p = 0.016$, respectively], and were significantly associated with lower odds of cognitive impairment [odds ratio (OR) = 0.69 (95% CI: 0.47–0.98); OR = 0.66 (95% CI: 0.45–0.95), respectively]. Compared with participants with ≤ 1 healthy lifestyle factor, the β (95% CI) of MMSE score for participants with 3, and 4–5 healthy lifestyle factors were 0.26 (0.08–0.44) and 0.25 (0.04–0.47), respectively; and the OR and 95% CI for participants with 3 healthy lifestyle factors were 0.59 (0.34–0.98). Adherence to multiple healthy lifestyle behaviors, particularly regular physical activity and adequate night sleep, was associated with better cognitive function among elders in Shanghai.

***Keywords*:** healthy lifestyle, cognitive function, community-dwelling elders, Shanghai, China

1. Introduction

With the rapid increase of the aging population in China, the prevalence of age-related diseases and conditions has markedly risen over the past decades (*1*). Among these, cognitive decline has emerged as a major public health concern, which impairs both life quality and work productivity, and substantially increases the risk of dementia (*2*). A nationwide survey conducted in China between 2015 and 2018 reported that approximately 15.5% of individuals aged 60 years and older experienced mild cognitive impairment, 6.0% were diagnosed with dementia, and 3.9% had Alzheimer's disease (*3*). These conditions not only severely affect individuals' quality of life but also pose a substantial burden on caregivers, families, and the financial and healthcare systems of society (*4*). However, cognitive decline does not necessarily lead to dementia and may be reversed or stabilized, thereby preventing progression to a pathological state (*5*). Therefore, identifying modifiable risk factors associated with cognitive impairment is essential for developing effective public health strategies and promoting healthy aging in China.

Extensive research has explored the risk factors of cognitive function, including aging, education, occupational status, chronic diseases, genetic and epigenetic factors as well as lifestyle behaviors (*6,7*). Among these, the management of a healthy lifestyle is becoming increasingly important (*2,8,9*). A growing body of evidence suggests that conventional modifiable healthy lifestyle factors, such as nonsmoking, moderate alcohol consumption, adequate sleep, normal body mass index (BMI), regular physical activity and adhering to a balanced diet rich in fruits, vegetables, fish and nuts, are all linked to better cognitive function and a reduced risk of dementia (*10,11*). However, lifestyle factors often cluster rather than act independently. Therefore, a combined healthy score, integrates multiple behaviors, has been proposed as a more comprehensive indicator of health outcomes.

Several large cohort studies in Western populations have consistently shown that adherence to multiple healthy lifestyle factors is associated with slower cognitive decline (*12*). In China, a few studies have examined this association. Jia *et al.* found that subjects with favorable lifestyle factors experienced a slower memory decline than those in the unfavorable group in a cohort of 29,072 participants (*2*). Wang *et al.* observed that those in the highest quartile lifestyle score had a lower risk of cognitive impairment [odds ratio (OR) = 0.52 (95% confidence interval (95% CI): 0.41–0.65] among 5,716 participants with an average age of 82 years from the Chinese Longitudinal Healthy Longevity Survey (*13*). Nevertheless, evidence among community-dwelling older adults in China remains limited.

To address this gap, this study aimed to examine the associations between adherence to multiple healthy lifestyle factors and cognitive function among community-dwelling older adults in Shanghai, China.

2. Materials and Methods

2.1. Study population

This cross-sectional study used a convenience sampling approach, including 1,043 community-dwelling residents of Pudong District, Shanghai, China, who participated in China's national free physical examination program between July and September 2024. Individuals were included if they met the following criteria: *i*) adults aged 60 years or older; *ii*) had lived in the community for at least one year; and *iii*) were willing to participate and able to communicate effectively. The exclusion criteria were as follows: *i*) aged < 60 years (n = 2); *ii*) previously diagnosed Alzheimer's disease or other dementias (n = 3); *iii*) missing lifestyle data (including BMI, smoking status, alcohol drinking status, sleep duration time and exercise data) (n = 96). The final analytic sample comprised 942 participants, who completed the questionnaire, physical examination, and informed consent.

This study was reviewed and approved by the Research Ethics Committee of Shanghai Health Medical University (2024-SSF-24-04-005). All participants provided written informed consent, and the study was conducted in accordance with the Declaration of Helsinki. All methods were performed in accordance with relevant guidelines and regulations and followed the Strengthening. Reporting of Observational Studies of Epidemiology (STROBE) guidelines (*14*).

2.2. Assessment of cognitive function

In this study, cognitive function was assessed using the Mini-Mental State Examination (MMSE), which consisted of 30 items scored from 0 to 30, with higher scores indicating better cognitive performance (*15*). Cognitive impairment was defined as MMSE scores ≤ 17 for illiterate individuals, ≤ 20 for those with primary education, and ≤ 24 for those with junior school education or above (*16*).

2.3. Assessment of lifestyle factors and covariates

Information on demographic characteristics (*e.g.*, age, gender, education, marriage, family income and co-residence status), lifestyle behaviors (*e.g.*, smoking, alcohol drinking status, physical activity, and sleep duration) and comorbidities was collected through face-to-face interviews using a semi-structured questionnaire.

Education levels included illiterate, primary school, junior or high school, and college or above. Marital status was categorized into single (single, divorced or widowed) or married. Family income was categorized into < CNY 5,000, 5,000–10,000, 10,001–20,000, and > 20,000 monthly. Co-residence status consisted of living with family and living alone. Current smokers were defined as subjects who smoked > 1 cigarette/day for more than 6 months, and former smokers were defined as subjects who ever smoked but had stopped smoking for more than 6 months; otherwise, they were defined as never smokers (*17*). Individuals who drank alcohol > 1 time/week for > 6 months were considered as current alcohol drinkers, and former drinkers were those who had abstained from drinking for > 6 months; otherwise, they were defined as never alcohol drinkers. To estimate the daily alcohol consumption, we multiplied the average alcohol content of each type of alcoholic beverage by the daily volume consumed for that type, and then summed the results across all types. The average alcoholicity of liquor, beer, wine and rice wine were 42%, 4%, 12% and 10%, respectively (*18*). Participants engaging in moderate or vigorous physical activity for at least 30 minutes per session, three or more times per week, were considered regular physical activity (*19*). Participants were queried about their usual bedtime and wake-up time, and sleep duration was determined by calculating the interval between these two times (*20*).

In our study, comorbidities were grouped into six categories: *i*) circulatory diseases (coronary heart disease, stroke, hypertension); *ii*) chronic obstructive pulmonary disease (COPD); *iii*) malignant tumors; *iv*) diabetes; *v*) liver diseases; and *vi*) kidney diseases. We categorized the number of comorbidities into four groups: none, one, two, and three or more diseases (*21*). Professionally trained staff used calibrated instruments to measure weight and height. BMI was calculated as weight (kg) divided by the height (m^2).

2.4. Healthy lifestyle score

Based on previous evidence, we considered healthy behaviors to include a BMI ranging from 18.5 to < 24 kg/m^2, regular physical activity, never smoking, light to moderate alcohol consumption (< 15 g/day for women and < 30 g/day for men), as well as sleeping for 7.0–9.0

hours per night (*21,22*). For each lifestyle, the individuals received a score of 1 if he/she met the criterion for healthy lifestyle and 0 otherwise. The overall healthy lifestyle score was calculated as the sum of these individual components, ranging from 0 to 5.

2.5. Statistical analysis

For continuous data, the median and interquartile range, ranging from the first to the third quartile, were displayed. Categorical variables were presented as frequencies and percentages. Descriptive analyses were first conducted to compare characteristics between participants with and without cognitive impairment using nonparametric and chi-square tests as appropriate. To facilitate comparison of effect sizes and improve model interpretability, MMSE scores were standardized using Z-score transformation before regression analyses. Linear regression models were applied to investigate the relationships between healthy lifestyle factors and MMSE scores, and logistic regression models were used to examine the relationships between healthy lifestyle factors and cognitive impairment status. We initially adjusted for age and gender (model 1); further adjusted for marital status, education level, monthly family income, co-residence status, the number of comorbidities (model 2); and further adjusted for the other four lifestyles when evaluating each lifestyle factor in these regression models (model 3). Subgroup analyses were conducted stratified by age, gender, marital status, education level, family income monthly and co-living status to explore potential heterogeneity in the associations.

Two-sided p values < 0.05 were considered statistically significant. All analyses were performed using R software (version 4.3.1; R Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. Baseline characteristics of study participants

The general characteristics of the study participants are shown in Table 1. A total of 942 community-dwelling older adults aged 64 to 88 years were included, comprising 389 men and 553 women. MMSE scores ranged from 5 to 30. Based on education-adjusted MMSE cutoffs, 148 participants (15.71%) were classified with cognitive impairment, whereas 794 (84.29%) had normal cognitive function. Compared with cognitive normal participants, those with cognitive impairment were older [aged: 71.00 (68.00–75.00) *vs.* 70.00 (67.00–73.00), p = 0.015], had lower monthly household income [> CNY 20,000: 5.41% *vs.* 10.58%, p < 0.001], slept longer at night [8.00 (7.00–9.00) *vs.* 8.00 (7.00–8.50), p = 0.007], and were less likely to be physically active [56.76% *vs.* 67.76%, p = 0.012]. They also had lower healthy lifestyle scores (p = 0.029).

3.2. Associations between healthy lifestyles and cognitive function

For regression analyses, MMSE scores were standardized to Z-scores to facilitate interpretation. Results of the linear regression analyses (Table 2 and Figure 1) showed that regular physical activity and optimal night sleep duration were positively associated with higher MMSE scores [β = 0.21 (95% CI: 0.09–0.34), p = 0.001; β = 0.15 (95% CI: 0.03–0.27), p = 0.016, respectively]. Compared with participants who had ≤ 1 healthy lifestyle factor, those with 3 and 4–5 healthy factors had significantly higher MMSE scores [β = 0.26 (95% CI: 0.08–0.44) and β = 0.25 (95% CI: 0.04–0.47), respectively; p for trend < 0.001].

Associations of individual healthy lifestyle factors and healthy lifestyle score with cognitive impairment status are shown in Table 3 and Figure 2. Regular physical activity or optimal night sleep duration was associated with lower odds of cognitive impairment [OR = 0.69 (95% CI: 0.47–0.98); OR = 0.66 (95% CI: 0.45–0.95), respectively]. Furthermore, a higher healthy lifestyle score (score = 3) was also associated with a reduced risk of cognitive impairment [OR = 0.59 (95% CI: 0.34–0.98)], compared to ≤ 1 healthy lifestyle factor.

3.3. Subgroup analyses

Subgroup analyses were conducted stratified by age, gender, marital status, education level, family income monthly and co-living status (Supplementary Tables S1-S6, *https://www.globalhealthmedicine.com/site/supplementaldata.html?ID=114*). The positive associations of regular physical activity and optimal night sleep duration with MMSE score were mainly observed among participants aged ≥ 70 years [β = 0.21 (95% CI: 0.05–0.37) and β = 0.24 (95% CI: 0.09–0.39), respectively], whereas these associations were not significant among those aged < 70 years (Supplementary Table S1, *https://www.globalhealthmedicine.com/site/supplementaldata.html?ID=114*). Among women, optimal night sleep duration was positively associated with higher MMSE scores [β = 0.18 (95% CI: 0.04–0.34), p = 0.014] (Supplementary Table S2, *https://www.globalhealthmedicine.com/site/supplementaldata.html?ID=114*) and women with 3 healthy lifestyle factors had better MMSE score [β = 0.29 (95% CI: 0.04–0.55), p = 0.026] (Supplementary Table S2, *https://www.globalhealthmedicine.com/site/supplementaldata.html?ID=114*).

When stratified by marital status, both regular physical activity and optimal night sleep duration were positively associated with MMSE scores among married participants (all p < 0.05, Supplementary Table S3, *https://www.globalhealthmedicine.com/site/*

Table 1. Characteristics of participants according to cognitive status

Variables	All participants	Cognitive impairment status		
		Yes	No	p^*
No	942	148	794	
Demographic factors				
Age (years old), median (IQR)	70.00 (67.00–74.00)	71.00 (68.00–75.00)	70.00 (67.00–73.00)	0.015
Males, *n* (%)	389 (41.30)	58 (39.19)	331 (41.69)	0.634
Marital status, *n* (%)				0.229
Single	156 (16.56)	30 (20.27)	126 (15.87)	
Married	786 (83.44)	118 (79.73)	668 (84.13)	
Education, *n* (%)				0.146
Primary school or below	381 (40.45)	69 (46.62)	312 (39.29)	
Junior or high school	533 (56.58)	77 (52.03)	456 (57.43)	
College or above	28 (2.97)	2 (1.35)	26 (3.27)	
Family income monthly (CNY), *n* (%)				< 0.001
< 5,000	194 (20.59)	53 (35.81)	141 (17.76)	
5,000–10,000	395 (41.93)	51 (34.46)	344 (43.32)	
10,001–20,000	261 (27.71)	36 (24.32)	225 (28.34)	
> 20,000	92 (9.77)	8 (5.41)	84 (10.58)	
Co-residence, *n* (%)				0.312
Living with family member	846 (89.81)	129 (87.16)	717 (90.30)	
Living alone	96 (10.19)	19 (12.84)	77 (9.70)	
Lifestyle factors				
Smoking status, *n* (%)				0.191
Never	661 (70.17)	112 (75.68)	549 (69.14)	
Current	143 (15.18)	21 (14.19)	122 (15.37)	
Former	138 (14.65)	15 (10.14)	123 (15.49)	
Alcohol drinking status, *n* (%)				0.794
Never	740 (78.56)	117 (79.05)	623 (78.46)	
Current	128 (13.59)	18 (12.16)	110 (13.85)	
Former	74 (7.86)	13 (8.78)	61 (7.68)	
Sleep duration (hours/night), median (IQR)	8.00 (7.00–9.00)	8.00 (7.00–9.00)	8.00 (7.00–8.50)	0.007
Regular physical activity, *n* (%)	622 (66.03)	84 (56.76)	538 (67.76)	0.012
Body mass index (BMI, kg/m^2), median (IQR)	24.50 (22.20–26.70)	25.20 (22.10–27.30)	24.50 (22.20–26.60)	0.172
Healthy lifestyle score, *n* (%)				0.029
0–1	170 (18.05)	32 (21.62)	138 (17.38)	
2	317 (33.65)	61 (41.22)	256 (32.24)	
3	329 (34.93)	38 (25.68)	291 (36.65)	
4–5	126 (13.37)	17 (11.48)	109 (13.73)	
Comorbidities				
No of comorbidities, *n* (%)				0.766
0	197 (20.91)	32 (21.62)	165 (20.78)	
1	273 (28.98)	46 (31.08)	227 (28.59)	
2	229 (24.31)	31 (20.95)	198 (24.94)	
3+	243 (25.80)	39 (26.35)	204 (25.69)	
Hypertension, *n* (%)	542 (57.54)	95 (64.19)	447 (56.30)	0.091
Stroke, *n* (%)	83 (8.81)	17 (11.49)	66 (8.31)	0.275
Diabetes, *n* (%)	209 (22.19)	35 (23.65)	174 (21.91)	0.720
CVD, *n* (%)	190 (20.17)	30 (20.27)	160 (20.15)	0.993
COPD, *n* (%)	26 (2.76)	3 (2.03)	23 (2.90)	0.749
Malignant tumors, *n* (%)	48 (5.10)	8 (5.41)	40 (5.04)	0.840
Liver diseases, *n* (%)	165 (17.52)	18 (12.16)	147 (18.51)	0.080
Kidney diseases, *n* (%)	48 (5.10)	6 (4.05)	42 (5.29)	0.672
MMSE score, median (IQR)	27.00 (24.00–29.00)	20.00 (16.00–23.00)	28.00 (26.00–29.00)	< 0.001

Note: Continuous variables were presented as the median (interquartile range, IQR), and categorical variables were presented as *n* (%). *Continuous variables were compared using the Kruskal-Wallis test, and categorical variables were compared by using Chi-square tests.

supplementaldata.html?ID=114). In analyses stratified by education, the positive associations of regular physical activity and night sleep duration with MMSE score remained significant in both the lower (primary school or below) and higher (junior high school or above) education groups (all p <0.05, Supplementary Table S4, *https://www.globalhealthmedicine.com/site/supplementaldata.html?ID=114*).

When stratified by family income monthly, the beneficial associations of physical activity and optimal night sleep duration were observed only among participants with monthly income ≤ CNY 10,000 [β = 0.22 (95% CI: 0.06–0.38) and β = 0.17 (95% CI: 0.02–0.32), respectively], but not in the higher-income group [β = -0.13 (95% CI: -0.37–0.10) and β = 0.16 (95% CI: -0.05–0.37), respectively]. Similarly, the

Table 2. Association between healthy lifestyle factors and MMSE score

Lifestyles	*n*	Model 1		Model 2		Model 3	
		β (95% CI)	*p*	*β* (95% CI)	*p*	*β* (95% CI)	*p*
Normal BMI							
No	545	Ref		Ref		Ref	
Yes	397	0.12 (-0.01–0.25)	0.062	0.08 (-0.04–0.20)	0.176	0.09 (-0.03–0.21)	0.151
Never smoking							
No	281	Ref		Ref		Ref	
Yes	661	-0.10 (-0.30–0.10)	0.316	-0.07 (-0.25–0.12)	0.315	-0.07 (-0.26–0.11)	0.437
Light to Moderate alcohol intake							
No	863	Ref		Ref		Ref	
Yes	79	0.03 (-0.20–0.27)	0.806	0.03 (-0.20–0.25)	0.817	0.02 (-0.20–0.23)	0.855
Regular physical activity							
No	320	Ref		Ref		Ref	
Yes	622	0.30 (0.16–0.43)	< 0.001	0.22 (0.10–0.35)	0.037	0.21 (0.09–0.34)	0.001
Optimal night sleep duration							
No	420	Ref		Ref		Ref	
Yes	522	0.17 (0.05–0.30)	< 0.001	0.15 (0.03–0.27)	0.001	0.15 (0.03–0.27)	0.016
Healthy lifestyle score							
0-1	170	Ref		Ref		-	
2	317	-0.06 (-0.13–0.24)	0.537	-0.01 (-0.18–0.17)	0.975	-	-
3	329	0.35 (0.17–0.54)	< 0.001	0.26 (0.08–0.44)	0.004	-	-
4-5	126	0.34 (0.11–0.57)	0.003	0.25 (0.04–0.47)	0.021	-	-
P_{trend}			< 0.001		< 0.001		

Note: MMSE scores were standardized (Z-score). Multiple linear regression models were used to impute the *β* (95% CI), with adjustment for age, gender (model 1); further adjusted for marital status, education level, family income, co-residence status and the number of comorbidities (model 2); and further adjusted for the other four lifestyles when evaluating each lifestyle factor in the regression models (model 3).

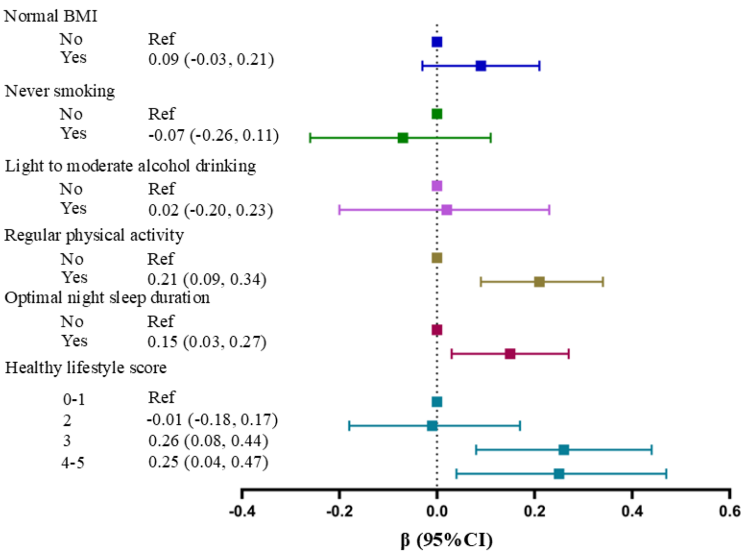

Figure 1. The associations between healthy lifestyle factors and MMSE score. Note: Multiple linear regression models were used to impute the *β* (95% CI), with adjustment for age, gender, marital status, education level, family income, co-residence status and the number of comorbidities and the other four lifestyle factors when evaluating each lifestyle factor in the regression models.

overall healthy lifestyle score was positively associated with MMSE score in the low-income group [*β* = 0.29 (95% CI: 0.07–0.51) for score = 3; *β* = 0.32 (95% CI: 0.04–0.59) for 4–5 healthy lifestyle factors], whereas no significant associations were found in those with higher income (Supplementary Table S5, *https://www.globalhealthmedicine.com/site/supplementaldata.html?ID=114*).

Finally, according to co-residence status, optimal night sleep duration was associated with higher MMSE scores in participants living with family [*β* = 0.14 (95% CI: 0.02–0.27), *p* = 0.022], while other lifestyle factors showed similar trends across the two groups (Supplementary Table S6, *https://www.globalhealthmedicine.com/site/supplementaldata.html?ID=114*).

Table 3. Association between lifestyle factors and cognitive impairment

Lifestyles	*n*	Model 1		Model 2		Model 3	
		OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Normal BMI							
No	545	Ref		Ref		Ref	
Yes	397	0.93 (0.66–1.33)	0.691	0.94 (0.65–1.37)	0.772	0.96 (0.65–1.40)	0.818
Never smoking							
No	281	Ref		Ref		Ref	
Yes	661	1.54 (0.89–2.66)	0.132	1.54 (0.87–2.71)	0.137	1.60 (0.89–2.85)	0.110
Light to Moderate alcohol intake							
No	863	Ref		Ref		Ref	
Yes	79	0.92 (0.44–1.80)	0.824	0.92 (0.43–1.82)	0.814	0.98 (0.46–1.95)	0.954
Regular physical activity							
No	320	Ref		Ref		Ref	
Yes	622	0.66 (0.46–0.94)	0.023	0.68 (0.47–0.98)	0.042	0.69 (0.47–0.98)	0.049
Optimal night sleep duration (hours/night)							
No	420	Ref		Ref		Ref	
Yes	522	0.63 (0.44–0.89)	0.016	0.64 (0.44–0.93)	0.018	0.66 (0.45–0.95)	0.024
Healthy lifestyle score							
0-1	170	Ref		Ref		-	
2	317	1.01 (0.62–1.66)	0.963	1.12 (0.68–1.87)	0.644	-	-
3	329	0.55 (0.32–0.95)	0.029	0.59 (0.34–0.98)	0.049	-	-
4-5	126	0.67 (0.34–1.28)	0.230	0.72 (0.36–1.40)	0.345	-	-
P_{trend}			0.023		0.044		

Note: Multiple logistic regression models were used to impute the OR (95% CI), with adjustment for age, gender (model 1); further adjusted for marital status, education level, family income, co-residence status and the number of comorbidities (model 2); and further adjusted for the other four lifestyles when evaluating each lifestyle factor in the regression models (model 3).

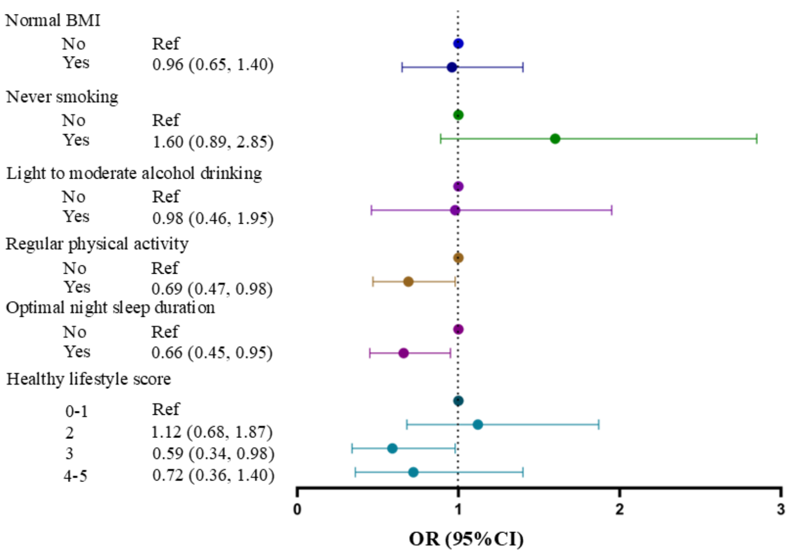

Figure 2. The associations between healthy lifestyle factors and cognitive impairment status. Note: Multiple logistic regression models were used to impute the OR (95% CI), with adjustment for age, gender, marital status, education level, family income, co-residence status and the number of comorbidities and the other four lifestyles when evaluating each lifestyle factor in the regression models.

4. Discussion

In this community-based cross-sectional study of older adults in Shanghai, we found that two healthy lifestyle factors (regular physical activity and optimal night sleep duration) were significantly associated with better cognitive function. Moreover, a higher overall healthy lifestyle score, defined from five healthy lifestyle components, was positively associated with MMSE scores in a dose–response manner. These findings provide population-based evidence from China supporting the importance of maintaining multiple healthy behaviors to promote cognitive health.

We found that regular physical activity was associated with higher MMSE scores and lower risk of cognitive impairment among Chinese elders [β = 0.21

(95% CI: 0.09–0.34), and OR = 0.69 (95% CI: 0.47–0.98)], consistent with previous evidence. The Lancet Commission on Dementia Prevention, Intervention, and Care identified physical inactivity as one of the major modifiable risk factors for dementia (*23*). A meta-analysis of thirty-seven cohort studies demonstrated that higher levels of physical activity were associated with a 35% reduced risk of cognitive decline [RR = 0.65 (95% CI: 0.55–0.76)] (*24*). Shanghai is a highly urbanized city with abundant community facilities and widespread health promotion programs for elders. Regular participation in group exercises such as tai chi and square dancing is common, contributing to higher physical activity and social engagement levels. In our sample, 66.03% of elders reported engaging in regular physical activity, whereas a nationally representative survey based on the China Family Panel Studies reported that only 39.1% of Chinese older adults participated in regular exercise (*25*). This higher prevalence of physical activity in Shanghai may partly explain the stronger association between physical activity and cognitive function observed in our study. Mechanistically, physical activity may enhance gray matter volume in the frontal and hippocampal regions and slow cortical thinning in memory-related areas such as the entorhinal cortex and medial parietal regions, thereby supporting better cognitive performance (*26,27*).

The present study showed that optimal night sleep duration of 7–9 hours was related to higher MMSE score [β = 0.15 (95% CI: 0.03–0.27)] and a lower risk of cognitive impairment [OR = 0.66 (95% CI: 0.45–0.95)]. These findings align with previous studies showing a U-shaped association between sleep duration and cognitive function. Ma *et al.* demonstrated that insufficient sleep (≤ 4 hours/night) or excessive (≥ 10 hours/night) were related to cognitive function decline among 20,065 participants from the English and Chinese cohort study (*28*). Similarly, Li *et al.* observed that sleep duration had an inverted U shape with cognitive scores, and both short (< 6 hours/day) and long sleep durations (> 8 hours/day) were associated with lower cognitive scores among 10,768 middle-aged and elder adults in the China Health and Retirement Longitudinal Study (*29*). Biologically, inadequate sleep may accelerate cortical thinning in frontotemporal regions, while excessive sleep has been associated with increased systemic inflammation, both of which can contribute to cognitive impairment (*30*).

However, in this study, no significant associations were observed for the other three lifestyle factors — nonsmoking, light to moderate alcohol drinking, and normal BMI, which differ from some previous reports (*31-34*). Participants recruited through community health examinations may represent a more health-conscious subgroup with fewer smokers and drinkers as well as healthier BMI. In addition, drinking in China is often embedded in social or festive contexts, making it difficult to isolate its biological effect on cognition from psychosocial influences. The relatively narrow BMI range in our sample and the inability of BMI to capture muscle mass or body composition may further obscure potential associations.

In our study, participants with 3 and 4–5 healthy lifestyle factors had significantly higher MMSE scores compared with those with one or none [β = 0.26 (95% CI: 0.08–0.44) and β = 0.25 (95% CI: 0.04–0.47), respectively]. However, only participants with 3 healthy lifestyle factors showed a significantly lower risk of cognitive impairment [OR = 0.59 (95% CI: 0.34–0.98)], while the association was not significant among those with 4–5 factors [OR = 0.72 (95% CI: 0.36–1.40)]. The lack of significance in the highest group may be due to the limited sample size. This finding is consistent with several large-scale studies. Wang *et al.* found that compared with subjects with one or none healthy behavior, those with 3 or 4 healthy lifestyle behaviors had 0.07 standard deviation higher cognitive Z-score in National Health and Nutrition Examination Survey 2011–2014 (*12*). Similarly, a study among African Americans and European American adults, showed that adherence to 4–5 healthy lifestyle factors was associated with a slower cognitive decline of 0.023–0.044 units/year (*35*). In a large European cohort study of 196,383 participants, Lourida *et al.* observed that participants with 4 healthy lifestyle factors exhibited a lower risk of Alzheimer's disease [HR = 0.64 (95% CI: 0.43–0.97)] compared to those without any healthy lifestyle factors (*36*). Together, these findings emphasize that adopting multiple healthy behaviors may be crucial for maintaining cognitive health and is positively associated with better cognitive function in older adults.

Subgroup analyses revealed that the associations between healthy lifestyle factors and cognitive function were more pronounced among elders, women and individuals with lower income. These findings suggest that sociodemographic context may modify the effects of healthy behaviors on cognition. Therefore, lifestyle-based cognitive health promotion in Shanghai should prioritize older adults with lower socioeconomic status.

The present study had several strengths. In this study, we conducted a comprehensive investigation into the relationships between healthy lifestyle factors and cognitive impairment. However, the study has several limitations to be addressed. First, this study used a convenience sample of elders who participated in a community-based physical examination program, which may have attracted individuals who were more health-conscious or in better health than the general elders. Therefore, selection bias cannot be completely ruled out, and the findings should be interpreted with caution when generalizing to other populations. Second, lifestyle behaviors, such as sleep duration or physical activity frequency, were self-reported and may be affected by recall bias or misreporting, although the interviews were conducted by trained personnel following a standardized protocol. Third, though the definition of regular physical activity is consistent with previous Chinese community-based studies (*19*), this self-reported measure may not fully capture non-exercise physical activity. Fourth, although we included healthy lifestyle factors based on the previous evidence (*21,22*), some important factors, such as dietary and psychological issues were not considered in the present study. Moreover, although key chronic diseases such as hypertension, diabetes and stroke, *etc*. were included in the comorbidity categories, the variable remained relatively coarse and might not fully capture disease severity. Therefore, residual confounding cannot be entirely ruled out. In addition, the results of subgroup analyses may still be limited by smaller sample sizes. Therefore, the results should be interpreted with caution.

In conclusion, our findings suggest that adhering to a greater number of healthy lifestyle factors was associated with better cognitive function among older adults in Shanghai. Particularly, regular physical activity and adequate night sleep duration were positively correlated with cognitive performance. Although causal relationships cannot be established from this cross-sectional design, these associations highlight the potential importance of healthy lifestyle behaviors for maintaining cognitive health in aging populations.

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