American Journal of Health Research
2025, Vol. 13, No. 3, pp. 168-177
https://doi.org/10.11648/j.ajhr.20251303.16

Research Article

Cognitive Decline Trajectories and Their Determinants in Middle-aged and Elderly Chinese

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Abstract

Objective: This study examined trajectories of cognitive decline in a large nationally representative sample of middle-aged and elderly people in Chinese during 5 years of follow-up, then, explored the factors that influenced the cognitive function decline. *Methods*: Data from the China Health and Retirement Longitudinal Study cohort (CHARLS: 2011-2015), were analyzed. Totally, 2379 participants (aged 45 years or older) were included. The Latent Class Growth Analyses (LCGA) were used to identify the potential heterogeneity in longitudinal changes of cognitive function and BMI (Body Mass Index) over the past 5 years. And Logistic Regression models were used to explore the factors affecting cognitive decline. *Results*: The mean score of baseline cognitive function was 14.14 (SD = 1.33). Three trajectories of cognitive function were identified: High-Slow decline (54.1%), Moderate-stable (34.9%), and Moderate-Rapid decline (10.9%). Maintaining a High BMI, living in urban, having a high level of education, people who drink but less than once a month tends to be associated with better cognitive function, older people with depression are more likely to suffer from cognitive decline. *Conclusions*: Cognitive function was identified into three trajectories in the Chinese middle-aged and elderly population. BMI, place of residence, alcohol consumption, age and depression were found to be potential determinants of cognitive decline, and these factors, especially the modifiable risk factors, should be controlled in life to reduce the occurrence of cognitive decline.

Keywords

Cognitive Function, LCGA, CHARLS

1. Introduction

Cognitive impairment is a major health problem in the aging population. With prevalence rates increasing year by year, and dementia have developed into major public health issues [2]. Growing body of evidence is emerging with regard to predictors of cognitive decline in older age. The most commonly investigated being sociodemographic, health, depression and health behaviour factors [3].

Currently, the factors affecting cognitive decline in middle-aged and older adults remains controversial. Some studies reported that people with a low BMI may be at risk for cognitive impairment, whereas a high BMI could be a protective factor for cognitive impairment in older adulthood [4]. It has also been reported that people over 65 with a high BMI are at increased risk of cognitive impairment and dementia [5]. Besides, Lifestyle and diseases has also received increasing attention as a modifiable behaviour because this factor is

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Received: 17 March 2025; **Accepted:** 18 May 2025; **Published:** 11 June 2025

relatively easily amendable with potential benefits for overall health as well as memory [6].

It has been proven that cognitive function changes both within and between individuals with increasing age. Therefore longitudinal repeated assessment of cognitive function is better than cross-sectional measures [7]. Many prior studies used body mass index (BMI) measured at one point in time as the primary exposure. The use of a single, point exposure fails to capture any variation and longitudinal patterns in disease risk that may occur because of changes in exposure. Alternative approaches to study adiposity include using body weight as a time varying exposure with multiple measurement time points, examining weight change (i.e., difference between two measurement time points), and using trajectory modeling approaches to assess change over time [8, 9]. In recent studies, latent class growth models (LCGA) have been used to describe a variety of different cognitive function, BMI, or body size trajectories in older adults [10]. The construction of LCGA models on BMI and cognitive function can determine that whether the trajectory of longitudinal BMI change over a long period of life plays a significant role in changes in cognitive function.

Based on the database of CHARLS (China Health and Retirement Longitudinal Study), this study classified cognitive function and BMI into different trajectories by constructing the LCGA model and investigated, and explored the factors affecting cognitive decline to prevent the development of cognitive impairment in the Chinese middle-aged and elderly population.

2. Methods

2.1. Study Population

The CHARLS was a nationally representative study of Chinese adults aged ≥45, which began in 2011 and aimed to describe the health, health insurance, and economic status of middle-aged and older adults after retirement dynamically in China. The data for this study were obtained from the 2011 CHARLS baseline survey and subsequent follow-up data on weight and cognitive function in 2013, 2015. Details of the study design, sampling procedures, and data collection have been described in previous studies [11]. In order to better investigate the influences associated with cognitive decline and to make the cognitive decline subgroup more distinct, we removed individuals who were below the baseline average, so that the LCGA subgroup would be more significant than the decline in the curve obtained by including all of them, thus making it more comparable. Individuals were included based on the following criteria: (1) Respondents who completed the cognitive assessment at baseline and all follow-up time points. (2) Respondents who provided data at baseline on gender, years of education, marital status, health insurance, chronic illness, sleep duration, physical and social activity, depression, height, and weight. (3) Baseline cognitive function scores were greater than the baseline population average. The detailed process for sample extraction was shown in Figure 1. Finally, 2,379 participants were included. Ethical approval for all CHARLS was obtained from the BHU Institutional Review Board. The IRB approval number for the main household survey including anthropometrics was IRB00001052-11, 015; the IRB approval number for the biomarker collection was IRB00001052-11, 014.

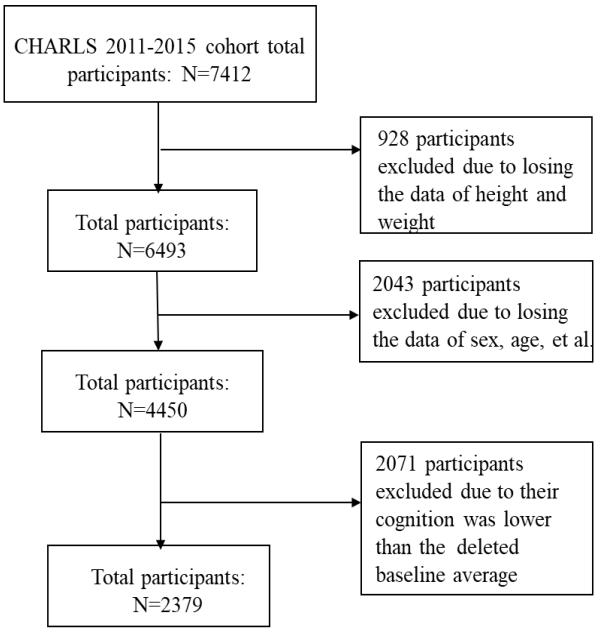

Figure 1. *Flow chart of participant enrollment.*

2.2. Assessment of Cognitive Function

Based on the HRS (Health and Retirement Study), CHARLS designed a composite battery of cognitive tests [12]. The reliability and validity of the assessments have been demonstrated in previous studies [13, 14]. Cognitive function was measured at 3 time points—the CHARLS 2011 baseline and 2013, 2015 follow-up surveys—using questionnaires that were adapted from the Telephone Interview for Cognitive Status [15, 16]. According to the cognitive tests, 2 dimensions of cognitive function were captured: episodic memory and executive function. Episodic memory was measured by immediate recall and delayed recall (score range, 0-10 points). Executive function was evaluated by orientation, calculation, and visuospatial ability (score range, 0-11 points) [15].

2.3. Other Measurements

Weight and height were measured objectively by trained investigators using standardized equipment. BMI was calculated as weight (kg)/ [height (m)]^2 [3]. Physical activity is calculated by the formula: Volume of VPA/LPA/MPA=Frequency of VPA/LPA/MPA*Duration of VPA/LPA/MPA Therefore, the volume of MVPA was then

coded as no MVPA OR not sufficient (≤600 MET)/ sufficient (600~2999MET)/ excessive (≥3000MET). Depression was measured with TICS (0–10). The following variables were included as covariates: age, sex (0=male, 1=female), marital status (0 = married, 1 = divorced/widowed/unmarried), place of residence (1=rural, 2=urban, 3=unified residence, dummy variable, reference group: rural), medical insurance (0 = no medical insurance, 1 = medical insurance), Physical activity(≤600MET-minutes/week, (600~2999)MET-minutes/week, ≥3000MET-minutes/week), Social Activities in one week (0=No, 1=Yes), Smoke (0=No, 1=Yes), Drink(0=No, 1= drink but less than once a month, 2= drink more than once a month), chronic diseases [17] (0 = no chronic diseases, 1 = 1 kinds of chronic diseases, 2 = more than 2 diseases), sleep duration, an education level (1 = illiterate, 2 = junior high school and below, 3 = high/vocational school, 4 = college and above, dummy variable, reference group: illiterate).

2.4. Statistical Analysis

Latent Class Growth Analysis (LCGA) models were used to identify different cognitive trajectories and BMI trajectories. In this study, trajectories were constructed by Mplus software [18], a process that started by specifying a level 1 LCGA model and then increasing the number of classes and comparing the fit of each model. The optimal number of groups was selected using a combination of the Akira Pool Information Criterion (AIC), Bayesian Information Criterion (BIC), Adjusted BIC (aBIC), Entropy, LMR-LRT, and BLRT test results. In addition, the proportion of each category was not less than 5% of the sample size, and the posterior probability of correctly assigning the study population to each category needed to be >0.80 [10, 19]. Statistical analyses were performed using IBM SPSS Statistics 26.0, with continuous variables expressed as means (SD) and categorical variable tables expressed as percentages. A χ^2 test or ANOVA was used to compare whether the variables differed between trajectory groups. Logistic models were used to analyze the factors affecting cognitive decline, and results were considered significant when $p<0.05$.

3. Results

3.1. Characteristics of the Participants

The average age of the participants was 67.33 years (SD = 7.81), the mean annual cognitive function score was [14.14 (SD = 1.33), 12.92(2.57), 12.64(2.63)] and the mean annual BMI was [24.02 kg/m^2 (SD = 3.50), 24.30 kg/m^2 (SD = 3.55), 24.18 kg/m^2 (SD = 3.61)]. In baseline, among the participants, 55.95% were male. 81.50% of the participants had only less than nine years of compulsory education; 93.15% of the participants were married; 74.44% of the participants had a rural residence, most participants (95.50%) had health insurance, 66.08% of the participants had less than two chronic illnesses. 58.50% of the participants have social activities in one week, 75.58% participants lack of physical activities, 56.49% participants never smoke and 62.23% participants never drink. The average sleeping time is 6.55 h (SD = 1.62) and the average depression scores is 6.71(SD = 5.54).

3.2. Results of the LCGA Model

3.2.1. Trajectory Model of Cognitive Function

In the LCGA model, there were groups where the proportion of people included in the trajectory was less than 5% of the sample size when they were divided into five groups (Table 1), and the posterior probability of a category was <0.80 when they were divided into four groups (Supplementary Table 1, Supplementary Table 2). Finally, the trajectories were divided into 3 groups. The trends of three trajectories groups were as follows (see Figure 2): (1) High-Slow decline group [Intercept: 15.56 ($p<0.001$), Slope: -0.449 ($p<0.001$)]: a group with cognitive function score that declined slowly (54.1%) from high levels. (2) Moderate-Stable group [Intercept: 12.95 ($p<0.001$), Slope:-0.040($p=0.328$)]: cognitive function score remained moderate over the three stages (34.9%). (3) Moderate-Rapid decline group [Intercept: 14.61 ($p<0.001$), Slope: -1.33 ($p<0.001$)]: cognitive function score declined rapidly (10.9%). Estimated means and estimated individuals values see in Supplementary Figure 1.

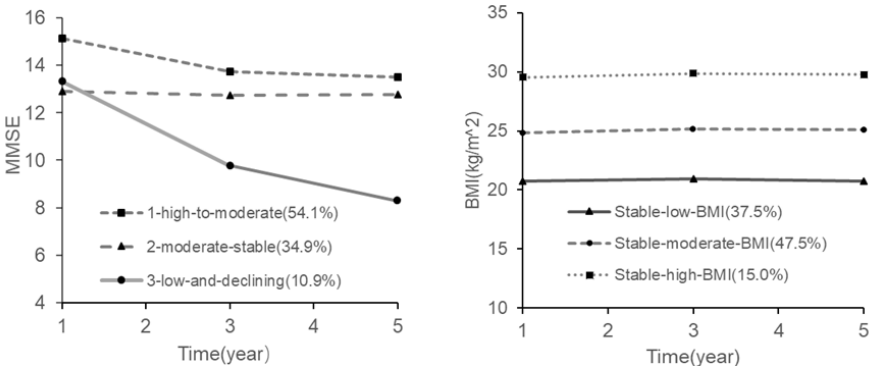

Figure 2. *Trajectories of cognitive function and BMI over 5 years of follow-up by LCGA.*

Table 1. Fit statistics for the LCGA of cognitive function trajectories and BMI trajectories.

Characteristic	class	AIC[a]	BIC[b]	aBIC[c]	Entropy	LMRT	BLRT	proportion
Cognitive function	1	30769.01	30797.88	30797.88	—	—	—	
	2	30053.27	30099.46	30074.04	0.715	<0.001	<0.001	21.5/78.5
	3	29797.79	29861.30	29826.35	0.735	<0.001	<0.001	34.9/10.9/54.1
	4	29635.51	29716.35	29671.87	0.740	<0.001	<0.001	44.6/34.38/12.0/9.0
	5	29493.69	29591.85	29537.84	0.748	0.024	<0.001	24.4/16.86/38.2/17.0/3.6
BMI	1	38356.35	38385.22	38369.33				
	2	34964.28	35010.48	34985.06	0.827	<0.001	<0.001	58.7/41.3
	3	33008.41	3371.93	33036.98	0.874	<0.001	<0.001	47.5/15.0/37.5
	4	32054.59	32135.43	32090.95	0.863	0.076	<0.001	39.6/27.8/25.5/6.8

Class: number of trajectories; AIC: Akaike information criterion. BIC: Bayesian information criterion. aBIC: Sample-size adjusted BIC. LMRT: Lo, Mendell and Rubin adjusted LRT; BLRT: Bootstrap LRT. Proportion: trajectory membership proportions; The bold text indicates the model that was selected as having the optimal number or classes.

Table 2. Characteristics between Trajectory Groups of Cognitive function[a].

CHARACTERISTIC	High-Slow decline (n = 1288)	Moderate-Stable (n = 831)	Moderate-Rapid decline (n=260)	TOTAL (n = 2379)	*P*[b]
BMI Trajectory Group					0.001
Stable-low-BMI	455(35.3)	312(37.5)	124(47.7)	891(37.5)	
Stable-moderate-BMI	617(47.9)	407(49.0)	106(40.8)	1130(47.5)	
Stable-high-BMI	216(16.8)	112(13.5)	30(11.5)	358(15.0)	
Age[c] mean (SD)	66.6 (7.8)	67.8(7.9)	69.5(7.8)	67.3(7.8)	<0.001
Place of residence					
rural	874(67.8)	661(79.5)	237 (91.2)	1771(74.4)	<0.001
urban	405(31.4)	167 (20.1)	21(8.1)	593(24.9)	
unified residence	10(0.8)	2(0.2)	2 (0.8)	14(0.6)	
Gender					
Male	743(57.6)	455(54.8)	134(51.7)	1332(56.0)	0.151
Female	546(42.4)	376(45.2)	12(48.3)	1047(44.0)	
Insurance					
Urban employee medical insurance	1232(95.7)	797(95.9)	243(93.5)	2272(95.5)	0. 234
Urban resident medical insurance	56(4.3)	34(4.1)	17(6.5)	107(4.5)	
Education					
No formal education illiterate	184(14.3)	214(25.8)	115(44.2)	513(21.6)	<0.001
Elementary /Middle school	796(61.8)	500(60.2)	130(50.0)	1426(59.9)	

CHARACTERISTIC	High-Slow decline (n = 1288)	Moderate-Stable (n = 831)	Moderate-Rapid decline (n=260)	TOTAL (n = 2379)	*P*[b]
High/Vocational School	260(20.2)	101(12.2)	14(5.4)	375(15.8)	
College degree or above	48(3.7)	16(1.9)	1(1.5)	65(2.7)	
Marriage					
Married	1210(93.9)	770(92.7)	236(90.8)	2216(93.1)	0.143
Divorced / Widowed/ Never married	78(6.1)	61(7.3)	24(9.2)	163(6.9)	
Number of Chronic diseases					
None	500(38.8)	267(32.1)	89(34.2)	856(36.0)	
1	374(29.0)	266(32.0)	77 (29.6)	716(30.1)	0.033
> 2	415(32.2)	298(35.9)	94(36.2)	807(33.9)	
Social Activities in one week					
No	495(38.4)	366(44.0)	127(48.8)	988(41.5)	0.002
Yes	793(61.6)	465(56.0)	133(51.2)	1391(58.5)	
Physical activities					
≤600MET-minutes/week	997(77.4)	605(72.8)	196(75.4)	1798(75.6)	0.151
(600~2999)MET-minutes/week	260(20.2)	196(23.6)	57(21.9)	513(216)	
≥3000 MET-minutes/week	31(2.4)	30(3.6)	7(2.7)	68(2.9)	
Smoke					
No	740(57.5)	457(55.0)	147(43.5)	1344(56.5)	0.537
Yes	548(42.5)	374(45.0)	113(43.5)	1035(43.5)	
Drink					
No	776(60.2)	527(63.4)	178(68.5)	1481(62.3)	0.003
Drink but less than once a month	144(11.2)	72(8.7)	10(3.8)	226(9.5)	
Drink more than once a month	388(28.6)	232(27.9)	72(27.7)	672(28.2)	
TICS (0–10), mean (SD)[c]	5.8(5.0)	7.5(5.9)	8.7(6.1)	6.7(5.5)	<0.001
Sleeping-time, mean (SD)[c]	6.6(1.5)	6.5(1.6)	6.2(2.0)	6.6(1.6)	0.002

[a] Data are presented as counts (percentage) unless otherwise indicated.
[b] P value determined using χ^2 test or analysis of variance F-test.
[c] For continuous variables, mean (SD) for each trajectory group and significance from analysis of variance F-test are reported.

3.2.2. Trajectory Model of BMI

LMRT test $P>0.05$ when divided them into 4 groups. Finally, the BMI trajectories were grouped into three groups by comprehensive consideration (Table 1), in which all posterior probabilities are greater than 0.9 (see Supplementary Table 2). The trajectory plots (Figure 2): (1) Stable-moderate-BMI (47.5%) [Intercept: 24.85 ($p<0.001$), Slope: 0.059 ($p<0.001$)], the average of the three follow-up time points was (24.84, 25.16, 25.07) kg/m^2 (2) Stable-high-BMI (15.0%) [Intercept: 29.54 ($p<0.001$), Slope: 0.061 ($p=0.019$)], the average of the three follow-up time points was (29.53, 29.85, 29.77) kg/m^2. (3) Stable-low-BMI (37.5%) [Intercept: 20.78 ($p<0.001$), Slope: 0.009 ($p=0.498$)], the average of the three follow-up time points was (20.73, 20.93, 20.76) kg/m^2. Estimated means and estimated individuals values see in Supplementary Figure 2.

3.3. Trajectory Characterization

There were significant differences among age, place of

residence, education, number of chronic diseases, social activities in one week, drink, depression and sleep duration in the three trajectories of cognitive function. Middle-aged and older adults who had low BMI, high age, low education level, have no social activities in one week, drink, have depression problem, a higher number of chronic diseases, rural residence, and less sleep duration had a higher probability of appearing in the Moderate-Rapid decline group, $P<0.05$, as detailed in Table 2 for comparison among groups.

3.4. Logistic Regression Analysis Model

Compared with Moderate-Stable group: In the Moderate-Rapid decline group, Stable-moderate-BMI group (odds ratio [OR], 0.655; 95% confidence intervals [CI], 0.486 to 0.833), urban (OR, 0.421; 95% CI, 0.272 to 0.653), elementary/middle school (OR, 0.484; 95% CI, 0.359 to 0.652), high/vocational School (OR, 0.258; 95% CI, 0.141 to 0.471), college degree or above (OR, 0.116; 95% CI, 0.015 to 0.888) and drink but less than once a month (OR, 0.448; 95% CI, 0.220 to 0.912) preventing cognitive function decline, age (OR, 1.029; 95% CI, 1.011 to 1.047) and depression (OR, 1.032; 95% CI, 1.009 to 1.056) had a risk effect on cognitive function; In the High-Slow decline group, the stable-high-BMI group (OR,1.322; 95% CI, 1.010 to 1.732), place of residence(OR, 1.792; 95% CI, 1.472 to 2.193), elementary/middle school (OR, 1.852; 95% CI, 1.476 to 2.322), high/vocational School(OR, 2.994; 95% CI, 2.212 to 4.052), college degree or above (OR, 3.489; 95% CI, 1.917 to 6.352), social activities in one week(OR, 1.261; 95% CI, 1.056 to 1.505), age (OR, 0.981; 95% CI, 0.970 to 0.992), 1 of chronic disease(OR, 0.749; 95% CI, 0.603 to 0.930), more than 2 of chronic disease (OR, 0.744; 95% CI, 0.603 to 0.918), physical activities>600MET-minutes/week (OR, 0.781; 95% CI, 0.639 to 0.955), depression (OR, 0.942; 95% CI, 0.927 to 0.958) were significantly different (Table 3 for detail).

Table 3. *Factors associated with trajectories of MMSE scores.*

Adjustment	Moderate-Rapid decline group[1]			High-Slow decline group [1]		
	OR	**95%CI**	***P***	**OR**	**95%CI**	***P***
BMI trajectory group						
Stable-low-BMI	1			1		
Stable-moderate-BMI	0.655	0.486,0.883	0.005	1.040	0.859,1.258	0.691
Stable-high-BMI	0.674	0.428,1.061	0.088	1.322	1.010,1.732	0.042
Age	1.029	1.011,1.047	0.002	0.981	0.970,0.992	0.001
Place of residence						
rural	1					
urbal	0.421	0.272,0.653	<0.001	1.792	1.472,2.193	<0.001
Gender						
Male	1			1		
Female	1.129	0.854,1.493	0.395	0.890	0.747,1.061	0.196
Insurance						
Urban employee medical insurance	1			1		
Urban resident medical insurance	1.640	0.900,2.987	0.106	1.066	0.689,1.647	0.775
Education						
No formal education illiterate	1			1		
Elementary/Middle school	0.484	0.359,0.652	<0.001	1.852	1.476,2.322	<0.001
High/Vocational School	0.258	0.141,0.471	<0.001	2.994	2.212,4.052	<0.001
College degree or above	0.116	0.015,0.888	0.038	3.489	1.917,6.352	<0.001
Marriage						
Married	1			1		

Adjustment	Moderate-Rapid decline group[1]			High-Slow decline group [1]		
	OR	95%CI	*P*	OR	95%CI	*P*
Divorced/Widowed/Never married	1.284	0.783,2.104	0.322	0.814	0.575,1.151	0.244
Number of chronic diseases						
None	1			1		
1	0.868	0.613,1.231	0.428	0.749	0.603,0.930	0.009
2	0.946	0.678,1.321	0.746	0.744	0.603,0.918	0.006
Social activities in one week						
No	1			1		
Yes	0.824	0.624,1.090	0.175	1.261	1.056,1.505	0.010
Physical activities						
≤600MET-minutes/week	1			1		
(600~2999)MET-minutes/week	0.898	0.641,1.256	0.529	0.818	0.650,1.029	0.086
≥3000 MET-minutes/week	0.720	0.311,1.66	0.443	0.696	0.495,0.978	0.037
Smoke						
No						
Yes	1.065	0.804,1.410	0.662	1.105	0.927,1.317	0.265
Drink						
No	1					
Drink but less than once a month	0.448	0.220,0.912	0.027	1.261	0.909,1.749	0.165
Drink more than once a month	1.088	0.795,1.490	0.598	0.928	0.761,1.132	0.462
TICS (0–10)	1.032	1.009,1.056	0.007	0.942	0.927,0.958	<0.001
Sleeping-time	0.907	0.837,0.984	0.018	1.039	0.983,1.099	0.175

Reference: Moderate-Stable group

4. Discussion

This study collected a nationally representative data of 2379 middle-aged and elderly Chinese from the CHARLS database. The LCGA model divided cognitive function and BMI into three trajectory groups, subsequent logistic regression analysis showed that high BMI, living in urban, having a high level of education, drink but less than once a month preventing cognitive function decline, older people with depression are more likely to suffer from cognitive decline.

Both changes in cognitive function and BMI were identified into three trajectories. A study based on four waves of data from the China Longitudinal Healthy Longevity Survey (CLHLS) identified cognitive function of older people into three trajectory groups with LCGA: stable cognitive group (SCG), high initial level-cognitive decline group (HIL-CDG), and high initial level-cognitive decline group (LIL-CDG) [20]. Also, a study on cognitive function of adults in Zaragoza, Spain, obtained 3 distinct trajectories with the best-fitting age-adjusted model: 1-high-to-moderate (21.2% of participants), 2-moderate-stable (67.5%) and, 3-low-and-declining (9.9%) cognitive function over time [21]. This study identified three unique trajectories of BMI over 5 years. In a study on BMI and cognitive function in Israel, BMI trajectories were identified into three groups, corresponding to "normal" (between 18.5 and 24.99 kg/m^2; 46%), overweight (between 25 and 29.99 kg/m^2; 43.6%) or obese (>30%; 10.3% kg /m^2), which is generally consistent with the classification of longitudinal changes in BMI in this study [22].

In the compared Moderate-Stable group and Moderate-Rapid decline group, we found that high BMI, live in urban, have a high level of education, drink but less than once a month preventing cognitive function decline, older people with depression are more likely to suffer from cognitive decline. Since the cognitive function scores were similar

in these groups at baseline, they were more comparable. These factors have been confirmed in previous studies: Martin Lövdén et al., observed the number of years of formal education completed by individuals is positively correlated with their cognitive function throughout adulthood and predicts lower risk of dementia late in life [23]. An Indonesian cross-sectional study showed that obesity in elderly individuals is less associated with cognitive impairment [24]. The above results were consistent with our findings. Hanzhang Xu et al., observed urban residents and urban-to-urban migrants had the highest levels of cognitive function, whereas rural residents and those who migrated to (or within) rural areas had the lowest cognitive function [25]. In several longitudinal studies, light-to-moderate drinking of alcoholic beverages has been proposed as being protective against the development of age-related changes in cognitive function [26]. Wentao Huang et al., suggest that depressive symptoms were associated with lower cognitive performance and larger subsequent decline during follow-up period [27].

In the compared Moderate-Stable group and High-Slow decline group, we found that the cognitive function scores for High-Slow decline group were higher than those for Moderate-Stable group even at the end of follow-up. Thus, even though the MMSE scores for High-Slow decline group decreased, overall cognitive function was still better than for Moderate-Stable. Individuals with high BMI, older, urban living, a higher level of education, drinking but less than once a month, social activities in one week, depression were more likely to appear in High-Slow decline group, individuals with physical activities more than 3000MET-minutes/week and chronic disease were more likely to appear in Moderate-Stable decline group. Lower social activity, higher physical activities and chronic disease may be the main reasons for the lower baseline levels in the moderately stable group rather than for the rapid decline in cognitive function. In a study on the relationship between social and intellectual activity and cognitive trajectories in middle-aged and older Chinese people: more frequent intellectual activities (OR 0.54, 95% CI 0.38–0.77) and social activities (OR 0.79, 95% CI 0.65–0.95) were both associated with a lower likelihood of being in the "persistently low trajectory" for global cognitive function [28]. A 12-year follow-up of cognitive function and its determinants in a longitudinal survey of healthy longevity in older people in China came to a similar conclusion to ours: leisure activity was not associated with rapid decline in cognitive function [29]. In a cross-sectional study on physical activity and its association with cognitive function in middle- and older-aged Chinese, it was concluded that compared with those who had no VPA, those who spent 6–7 days/week ($\beta = -0.59$, 95% CI: −1.10, −0.09) or more than 240 min/each time on VPA had poorer cognitive function among rural respondents [30]. A Cross-sectional structural equation model found that more depressive symptoms and chronic conditions, the worse the cognitive performance [31]. While, in longitudinal trajectory studies on cognitive function, the heart failure literature reports stable trajectory of change in attention, executive function and processing speed over 6 months to 1 year [32]. Cognitive function was stable for 3 years in people with chronic obstructive pulmonary disease [33].

Conventional growth model approaches such as the multilevel, random-effects model, assumes that the growth trajectories of all individuals can be adequately described with a single estimate of growth parameters. LCGA models relax this assumption and allow for differences in growth parameters across unobserved subpopulations using latent trajectory classes [10, 34]. LCGA model is increasingly recognized because of its excellent performance in identifying homogeneous subgroups of heterogeneous populations and the meaningful groups or individual classes. LCGA trajectory modeling can assess trends in cognitive function and BMI over time for different individuals during follow-up. Based on the epidemiological theory of the life course, exposures during specific life periods can greatly influence the development of diseases in later life [35].

The present study has several strength: (1) It followed a relatively large nationally representative cohort of Chinese middle-aged and older adults and provided a complete assessment of cognitive function. (2) In this study, the trajectory model (LCGA) was used to assess cognitive aging trajectories, which helped to identify individuals with similar changes in cognitive function over time. (3) Efforts were made in this study to mitigate the impact of unstable BMI on the results, in order to reduce bias. It has been suggested that at an older age, the stability of BMI may confer protection against cognitive decline, irrespective of the initial BMI of the individual [36]. This study divided BMI into three stable trajectories, thus avoided the impact of BMI changes on outcomes during follow-up and better investigated the impact of different levels of BMI on cognitive function.

The present study has several limitations: (1) First, the trajectory of those with severe cognitive impairment could not be observed due to the strict exclusion of those with low cognitive function at baseline. (2) No trajectory of BMI change was observed due to the small change in weight during old age combined with the short follow-up period. (3) Some covariates, such as socioeconomic status, were not included in the regression model due to the low response rate, such as gait speed. (4) Problems with trajectory grouping have hindered research into the factors that influence the slow decline in cognitive function.

5. Conclusions

Older adults with a high BMI, living in urban areas, having a high level of education, drinking alcohol less than once a month, and suffering from depression are more likely to experience a decline in cognitive function. In the comparison of different cognitive function trajectory groups, various factors related to depression and changes in cognitive func-

tion have been identified.

The LCGA model has demonstrated its advantages in this study for evaluating the trends of cognitive function and BMI over time. Moreover, the research sample is nationally representative, the model application is reasonable, and the handling of BMI effectively reduces bias.

For future research, it is advisable to include more older adults with poor cognitive function, extend the follow-up period to comprehensively observe the change trajectories of BMI. At the same time, it is necessary to further improve the consideration of covariates such as socioeconomic status, and conduct in-depth exploration of the relationship between cognitive function and BMI as well as the influencing factors, so as to provide a more comprehensive basis for interventions aimed at promoting the cognitive health of the elderly.

Acknowledgments

We would like to acknowledge the China Health and Retirement Longitudinal Study cohort (CHARLS) database for providing the dataset for analysis.

Ethics Statement

The data that support the findings of this study are available from CHARLS but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of CHARLS.

Author Contributions

CYK and ZGP and LL designed the study, analyzed and interpreted data. XKY, LJX, RZW, BBW, and MD interpreted data. All authors critically revised and approved the manuscript.

Funding

The Key Research Project for Colleges and Universities in Henan Province, Grant/Award Number: 23B330005.

Data Availability Statement

The dataset supporting the conclusions of this study is available in the CHARLS database.

Conflicts of Interest

The authors have no conflicts to report.

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