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ARTICLE

Gendered leisure time-use and its impact on cognitive function among older adults in rural China

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Abstract

Increasing evidence has shown that an active, socially engaged lifestyle in leisure time might protect older adults against the decline of cognitive function. It remains unclear, however, which types of leisure activities are more beneficial to maintain cognitive function, and whether there are gender differences in the association between leisure activities and cognitive function. We used a two-wave of panel data from 1,018 older adults aged 60 and older in rural China to examine the lag effects of different types of leisure activities on cognitive functioning and to identify the gender differences in their impacts on cognition in rural China. Ordinary least-squares regression models showed that high physical activities were associated with better cognitive function. High intensity of cognitive activities and engaging in physical activities have a protective effect on cognitive function among older men rather than older women. Further, we found that cognitive activities had a stronger effect on cognitive function among older men than older women. It is important to consider gender-specific intervention in leisure activities to maintain cognitive function among older adults.

Keywords: leisure activity; time-use; cognitive function; gender difference; China

Introduction

Fast population ageing, especially in developing countries, will lead to increasing numbers of older adults living with dementia (D Ding *et al.*, 2015). In China, it is estimated that people with dementia increased from 3.68 million in 1990 to 9.19 million in 2010 (Chan *et al.*, 2013). Particularly, the prevalence of dementia is notably higher in rural China than in urban China (6.05% *versus* 4.40%) (Jia *et al.*, 2014). Identifying ways to delay cognitive decline among older adults has become a key public health priority for ageing societies (Fancourt and Steptoe, 2018), as cognitive impairment is associated with worse quality of life (Pan *et al.*, 2015) and increased functional limitation (Zheng *et al.*, 2016). Leisure activities,

constituting a primary part of daily life in later life, are usually considered to have beneficial effects on cognitive function (Wang *et al.*, 2013). The association between leisure activities and cognitive function has attracted growing interest in recent decades (Fratiglioni *et al.*, 2004; Leung *et al.*, 2010; Iwasa *et al.*, 2012).

To date, evidence on the effect of different types of leisure activities on cognitive function using longitudinal data is limited. Many studies examining the association between a specific type of leisure activity failed to consider other types of activities simultaneously. The independent effects of different types of leisure activities on cognitive function may be not equally beneficial. For example, cognitively stimulating activities were found to be more protective against cognitive decline among older adults compared to physical activities (AT Lee *et al.*, 2018). Therefore, identifying the type of leisure activities that have the strongest effect on cognitive function would be helpful in developing target interventions to promote cognitive function.

Moreover, previous studies based on general social surveys lack a consistent definition and operationalisation of leisure activities (Leung *et al.*, 2010). A daily diary time-use study for leisure activities which is considered more precise and accurate than general social surveys may provide a better understanding for the benefits of leisure activities in the course of a single day (Ver Ploeg *et al.*, 2000). Further, the gender differences in the association between leisure activities and cognitive function are scarce (Bielak, 2010; Wang *et al.*, 2013; Hassing, 2020). The gendered pattern of leisure activities may have significant differences in the association between leisure activities and cognitive function.

To fill these gaps, the study aims to examine the effect of different types of leisure activities on cognitive function among older adults in rural China. We also explore gender differences in these associations.

Background

Theoretical framework

Guided by the 'use it or lose it' hypothesis of cognitive ageing (Salthouse, 1991) and the environmental complexity hypothesis (Schooler, 1987), we speculate that cognitive activities, physical activities, social connecting and social activities are positively associated with cognitive function, while sedentary sitting is negatively associated with cognitive function. In addition, there may be gender differences in the associations between different types of leisure activities and cognitive function. The 'use it or lose it' hypothesis of cognitive ageing emphasises that engagement in cognitive, physical and social activities in later life facilitates the maintenance or improvement of general cognitive abilities by 'exercising' them through the application in an individual's environment (Salthouse, 1991). On the contrary, spending time idling or doing nothing, such as sedentary sitting, may be negatively associated with cognitive function. This hypothesis provides us with the guidance for assessing the association between different types of leisure activities and cognitive function.

Furthermore, according to the environmental complexity hypothesis, people who participate in activities that require significant cognitive demands will have

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better cognitive function than those who are in less-complex environments with fewer cognitive demands. The gendered leisure activities may make older women participate in activities that require more minimal cognitive demands. Therefore, there may be gender differences in the association between different types of leisure activities and cognitive function.

Different types of leisure activities and cognitive function

In some studies, a high frequency of specific cognitive activities (*e.g.* reading, watching television (TV) were identified as risky factors for cognitive decline due to sedentariness (Rundek and Bennett, 2006; Hamer and Stamatakis, 2014). However, strong evidence in China shows that a higher frequency of cognitive activities including watching TV, listening to the radio, or reading books or newspapers is associated with less cognitive decline and a lower risk of cognitive impairment and dementia (Zhu *et al.*, 2017; AT Lee *et al.*, 2018; Mao *et al.*, 2020). Given the fewer leisure opportunities and the relatively low level of education among rural Chinese older adults, even the sedentary cognitively stimulating activities may protect their cognitive function.

Sufficient physical activities have consistently been proven to promote cognitive performance or reduce the risk of incidence of dementia (Etgen *et al.*, 2010; Buchman *et al.*, 2012; Willey *et al.*, 2016; Livingston *et al.*, 2017). A systematic review also suggests that high physical activity benefits cognitive function among older Chinese adults (Lü *et al.*, 2016). Social connecting and participation in social activities benefits cognitive function among older adults as well (Zunzunegui *et al.*, 2003; Choi *et al.*, 2016; Fu *et al.*, 2018; Tomioka *et al.*, 2018).

Moreover, one earlier study exhibited gender differences in the association between leisure activities and different domains of cognitive function. Higher levels of self-improvement, including physical activities and study, are associated with higher levels of cognitive function, whereas cognitive activities and social activities are only associated with better verbal ability and memory among older women (Hassing, 2020). In addition, the negative impact of sedentariness on cognition in older age is stronger for females (Fagot *et al.*, 2019). Given the gendered pattern of leisure activities in rural China, there may also be gender differences in the associations between different types of leisure activities and cognitive function.

Leisure activities of older adults in rural China

Compared with urban older adults, rural older adults are less active in both mental and physical activities (Su *et al.*, 2006). For example, rural older adults were twice as likely as their urban counterparts to spend time idling or doing nothing (Su *et al.*, 2006). The rural Chinese older adult is the vulnerable group as a result of unequal leisure opportunities in the Chinese context. Low education and life-long poverty among rural older adults may affect their leisure involvement (Cao *et al.*, 2020). Particularly, due to China's traditional dichotomous system, relative economic disadvantage makes rural residences have a disadvantaged position in the distribution of basic social resources, such as having cultural, wellness and recreational facilities (*e.g.* senior activity centres, chess rooms), when compared with residences in urban

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areas (C Ding *et al.*, 2018) which, in turn, may further constrain residences' leisure participation.

In Chinese families, men spent more time on leisure activities than women, as women are still doing the majority of domestic work (Luo and Chui, 2018). The gender differences in socio-economic status, social roles, family responsibilities and health status, along with the deficient supplying of public leisure resources, may lead to gendered patterns of leisure activity participation among older adults in rural China (W Zhang *et al.*, 2017; Chen and Tsai, 2020). Under Chinese patriarchal society, older women have fewer economic resources, and assume more caregiving roles and family responsibilities (Li *et al.*, 2009; Chen and Tsai, 2020). Moreover, older women are predominantly affected by debilitating illnesses and functional limitations (Agahi and Parker, 2008). Therefore, it is important to analyse older women and older men separately when examining the relationship between participation in leisure activities and cognitive function.

In addition to cognitive activities, physical activities and social activities that are included in numerous studies, we also include social connecting and spending time idling or doing nothing (*i.e.* sedentary sitting) to capture the participation in leisure activities among older adults in rural China. By distinguishing the difference between social engagement and solitary activity, between active leisure and sedentary leisure (Lennartsson and Silverstein, 2001; Simone and Haas, 2013; Wang *et al.*, 2013; Y Lee *et al.*, 2019), leisure activities in rural China include five categories: sedentary sitting, cognitive activity (including watching TV, reading books/newspapers, listening to the radio, surfing the internet), physical activity (*e.g.* sports, walking, dancing), social connection (including making phone calls, chatting, playing chess) and social activities (*e.g.* community affairs, volunteering, religious activities).

The present study

Though multi-disciplinary studies have confirmed the health benefits of active, socially engaged leisure activities in later life, it remains uncertain which types and what level of engagement are required for potential benefits to accrue in rural China. Especially, we know little about gendered patterns of leisure activities and whether the impact of leisure activities on cognitive capacity is gender-specific. In the present study, the aim is to examine the independent associations between different types of leisure activities and cognitive function. More specifically, the focus will be on the following questions:

(1) What are the relationships between different types of leisure activities and cognitive function?
(2) Are the associations between leisure activities and cognition gender-specific?

Methods

Data collection

The present study used data from the longitudinal survey 'Well-being of Elderly Survey in Anhui Province (WESAP)', which has been conducted every three

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years between 2001 and 2018 in rural townships in Chaohu, Anhui Province. Anhui Province is located in the eastern-central region of China, where more than half (57.9%) of the population lived in rural areas in 2009, which is a little higher than the national average of 53.4 per cent, and its economic development is about national average (National Bureau of Statistics of China, 2010). This region was chosen specifically for its relatively high density of older adults and high levels of out-migration of working-age adults (Cong and Silverstein, 2011). Using a stratified multi-stage sampling design, a questionnaire survey was administered to the randomly chosen residents aged 60 and older from 72 randomly selected villages within six rural townships. For the first-wave household interview in 2001, 1,800 older adults were identified as eligible respondents and 1,715 of them completed the baseline survey. All of the follow-up surveys include re-interviews with surviving respondents. This study used data from the 2015–2018 surveys as the time-use diary data were collected for the first time in 2015. Among the 1,243 participants interviewed in 2015, 128 had died by the 2018 survey and 95 were lost to follow-up across the two-wave surveys. Two cases with missing values in daily time-use were also deleted. ||Finally, 1,018 older adults were included in the subsequent analyses.

Measures

Dependent variables: cognitive function

The dependent variable was cognitive function measured in 2018. This measure was adapted from the Short Portable Mental Status Questionnaire (SPMSQ) (Pfeiffer, 1975). The SPMSQ has been widely used to screen for cognitive dysfunction, which captures four dimensions of an older adult's cognition dysfunction: orientation to time and place, current event information, memory and calculation (Welch and West, 1999; Malhotra *et al.*, 2013). The noteworthy feature of the SPMSQ is that it takes into consideration individuals' educational attainment, which could influence test performance (Pfeiffer, 1975). The sample questions are 'When were you born?', 'How old are you?' and 'What is the name of the district/county/town where you live?' To acquire better understanding and acceptability among Chinese older adults, some items were modified according to the Chinese context. For example, the participants were asked 'Who is the national chairman of China?' and 'Who was the national chairman of China before him?' The validity of the SPMSQ has been established in older Taiwanese adults (Tsai and Chang, 2019). Previous studies suggest that respondents tend to be unable to answer particularly difficult tasks when they have cognitive limitations (Xu *et al.*, 2017). Following recommendations in the previous literature, we counted responses of 'unable to answer' as incorrect answers (Herzog and Wallace, 1997; Z Zhang *et al.*, 2008; Xu *et al.*, 2017). Each item of the SPMSQ was coded as 1 if the participant responded correctly to the item, otherwise it was coded as 0. The alpha for this scale was 0.80. Total correct responses ranged from 0 to 10, with a higher score indicating better cognitive function.

Key independent variables: leisure-time activities

A comprehensive 24-hour recall measure was developed for participants' time used during the day prior to the date of survey completion, which has been widely used in previous surveys (*e.g.* the American Time Use Survey) or studies as a general

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time-use data collection instrument (Sabbath *et al.*, 2016; Pepin *et al.*, 2018). Daily diary time-use surveys, which can provide a detailed view of all activities in which older people engage over the course of a single day (Lam and García-Román, 2020), are considered more precise and accurate than general social surveys or so-called stylised questions (asking the number of hours in the past week or month that a participant engaged in a given activity) (Ver Ploeg *et al.*, 2000).

Investigators applied this time-use instrument to calculate the amount of time spent daily on activities such as housekeeping, care-giving, working at home, working away from home, leisure time and sleep. Because the time-use and allocation of leisure time is more likely to reflect older adults' own preferences, in this study we will focus on how older people spent their leisure time to explore the impact of active life engagement on the cognitive function of older adults. Leisure activities among older adults in rural China have been classified into five categories: sedentary sitting, cognitive activities, physical activities, social connecting activities and social activities.

The amount of time spent on the activities of each category was calculated in minutes. Because there is tremendous variation and skewness in the distribution of these leisure-time activities, we recoded these continuous variables of the daily time-use in each of the five categories into three levels of intensity: none, low intensity (average and less than average) and high intensity (more than average). Leisure activities are context-specific even within a similar socio-cultural society; diversity may also be observed due to subcultural variations (Ip, 2009). Therefore, we divided the intensity of each leisure activity based on its own practice or popularity in local areas. Overall means were used as reference in defining the cut-off points in this study. The intensity of participation in different types of leisure activities was measured in 2015.

Control variables

The socio-demographic variables of age, gender, marital status, education and family income, which had been identified as important factors of health and time-use of older people, were measured in 2015 and controlled in the data analysis. Age was assessed as a continuous variable. Gender was measured as female *versus* male (male = 1). Marital status was categorised as 'married' and 'single', with the latter including unmarried, divorced or widowed. Education was measured as the highest level of education achieved and divided into two categories: illiterate and primary school or above. Family income was assessed by the total amount of earnings of the individual and his or her spouse in the previous 12 months, including pensions, part-time income and earnings from self-employed activities. It was transformed using ln + 1 in the regression models.

Time spent on economic and household work, living arrangement and previous health condition, including presence of chronic disease and activities of daily living (ADLs), in 2015 were also included as potential confounders. The amounts of time spent on economic and household work were calculated in minutes, respectively, which were also obtained from the comprehensive 24-hour recall measure. Living arrangement was coded as a dichotomous variable: others = 0, living alone = 1. Incidence of chronic disease was assessed by three dichotomous variables of diabetes (having diabetes = 1), hypertension (having hypertension = 1) and cardiovascular disease (having heart disease or stroke = 1). ADLs reflect an individual's capability to perform a set of personal actions of daily living, activities requiring

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physical strength, mobility and flexibility, and instrumental activities of daily living. For each activity, the results are scored as 3 if the respondent was able to perform that activity 'independently', 2 if he or she 'needed help' and 1 if he or she was 'dependent'. The summed variable ranges from 15 to 45, with a higher score indicating better capability of performing these activities.

Since our analysis examined changes in cognitive function, we controlled for 2015 cognitive function, which was measured by the same scale as in 2018. Using this approach could minimise the risk of endogeneity in our specification in the event that cognitive function influences the participation in leisure activities.

Data analysis

We first ran descriptive statistics to summarise sample characteristics in 2015. Independent sample *t*-tests or one-way analyses of variance were conducted to examine the gender difference in the sample characteristics and core variables, including leisure activity and cognitive function. We used ordinary least-squares (OLS) multiple regression to examine the lagged and dynamic effect of leisure activities on older people's cognitive function at the second wave of measurement. We estimated a basic model of the associations between leisure-time activities in 2015 and cognitive function in 2018 (Model 1). Model 2 examined the above associations after controlling the socio-demographic characteristics of respondents in 2015. Incidence of chronic disease and ADLs in 2015 were added to Model 3 and cognitive function in 2015 were also controlled in Model 4. By doing so, we can examine how the magnitude of the effect changes by adding these covariates. Analyses were conducted on the total sample, and then stratified by gender. All analyses were conducted using Stata 15 software. $p < 0.05$ was considered as being significant based on two-tailed tests.

Results

Table 1 shows the characteristics of the sample in 2015. Of the 1,018 participants in the study, 518 (50.88%) were men. The average age was 70 years old (ranging between 60 and 98), with over 70 per cent married; 63.33 per cent of the participants were illiterate. On average, the annual income of the participants was about 6,640 Yuan (Chinese currency, equal to US $980) and the daily time spent on economic and household work was about 3.36 and 2.57 hours. Twenty per cent of the participants lived alone, and the percentages of participants having diabetes, hypertension and cardiovascular disease accounted for 8.63, 38.73 and 21.18 per cent, respectively. In terms of gender differences among participants, only living arrangements and presence of hypertension did not exhibit significant difference. Compared with older women, older men were younger, more likely to be married, more educated and with better health conditions, spent less time on household work rather than economic work and were less likely to live alone. The cognitive functioning in 2015 and 2018 are also shown in Table 1. There was a little decline of the participants' cognitive function on average, and older men reported higher levels of cognitive function than older women.

Table 2 shows the leisure time-use patterns and its gender difference among older adults in rural China. In this sample, the time spent on sedentary sitting

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Table 1. Characteristics of the sample and gender difference

Variables	Whole sample	Older men	Older women	*p*
N	1,018	518	500	
Mean age (SE) in 2015	70.05 (7.77)	69.59 (7.19)	70.54 (8.30)	0.024
Marital status in 2015 (%):				<0.001
Married	72.65	79.54	65.54	
Single	27.35	20.46	34.46	
Education attainment in 2015 (%):				<0.001
Illiterate	63.33	44.02	83.27	
Primary school	29.80	44.79	14.34	
Middle school and above	6.87	11.20	2.39	
Mean annual income (SE) in 2015 (Yuan)	6,639.54 (9,243.69)	7,451.74 (10,043.21)	5,801.46 (8,265.47)	0.002
Mean minutes per day (SE) spent on economic work in 2015	201.73 (212.76)	250.20 (227.10)	151.52 (183.99)	<0.001
Mean minutes per day (SE) spent on housework in 2015	154.40 (146.10)	103.27 (119.81)	207.38 (152.00)	<0.001
Living arrangement in 2015 (%):				0.301
Living alone	20.00	18.73	21.31	
Living with others	80	81.27	78.69	
Diabetes in 2015 (%):				0.009
Presence	8.63	6.37	10.96	
No	91.37	93.63	89.04	

Hypertension in 2015 (%):				0.472
Presence	38.73	37.64	39.84	
No	61.27	62.36	60.16	
Cardiovascular disease in 2015 (%):				0.010
Presence	21.18	17.95	24.50	
No	78.82	82.05	75.50	
ADLs in 2015 (SE)	41.77 (5.46)	42.70 (4.93)	40.81 (5.81)	<0.001
Cognitive ability in 2015 (SE)	7.49 (2.58)	8.43 (2.05)	6.53 (2.52)	<0.001
Cognitive ability in 2018 (SE)	7.12 (2.73)	8.14 (2.30)	6.06 (2.73)	<0.001

Notes: SE: standard error. ADLs: activities of daily living.

Table 2. Descriptive statistics of leisure-time activities in 2015 and gender difference

Variables	Whole sample	Older men	Older women	*p*
N	1,018	518	500	
Sedentary sitting:				
Mean minutes per day (SD)	133.85 (124.24)	126.67 (113.67)	141.30 (134.02)	0.030
Intensity (%):				0.091
None	15.13	13.90	16.40	
Less than average	60.22	63.51	56.80	
More than average	24.66	22.59	26.80	
Cognitive activity:				
Mean minutes per day (SD)	109.87 (108.39)	122.51 (116.66)	96.78 (97.51)	<0.001
Intensity (%):				0.019
None	24.75	21.04	28.60	
Less than average	46.76	48.65	44.80	
More than average	28.49	30.31	26.60	
Physical activity:				
Mean minutes per day (SD)	39.70 (73.09)	46.28 (81.46)	32.87 (62.61)	0.002
Intensity (%):				0.052
None	63.75	60.23	67.40	
Less than average	22.40	24.13	20.60	
More than average	13.85	15.64	12.00	
Social connection:				
Mean minutes per day (SD)	82.67 (114.95)	78.68 (115.06)	86.80 (114.81)	0.260
Intensity (%):				0.171
None	51.47	53.86	49.00	
Less than average	26.42	26.25	26.60	
More than average	22.10	19.88	24.40	
Social activity:				
Mean minutes per day (SD)	4.31 (37.83)	4.26 (34.39)	4.36 (41.13)	0.964
Intensity (%):				0.949
None	97.25	97.10	97.40	
Less than average	1.87	1.93	1.80	
More than average	0.88	0.97	0.80	

Note: SD: standard deviation.

was about 134 minutes per day on average, and only 15.43 per cent of participants reported that they did not spend time on sedentary sitting. On average, older adults spent about 110 minutes on cognitively stimulating activities, 40 minutes on physical activities, 83 minutes on social connections and 5 minutes on social activities.

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Less than 25 per cent of the participants did not spend time on cognitive activity, but over 60 per cent of the participants did not spend time on physical activity. In terms of social engagement, almost half the participants reported they spent no time on social connections, while over 97 per cent of the participants did not spend time on any social activity. The personal time-use shows gender patterns. Older women were less likely to spend time on cognitive activities than older men. Older men spent more time on cognitive or physical exercise while older women spent more time on sedentary sitting. There was no significant gender difference in time allocation to social engagement.

The associations between leisure activities in 2015 and cognitive function in 2018 were examined with an OLS regression (shown in Table 3). In Model 1, sedentary sitting, cognitive activities, social connection and social activities were significantly associated with subsequent cognitive function. However, in Model 4, when we controlled socio-demographic characteristics, health conditions and the baseline cognitive function, the impacts of sedentary sitting, cognitive activity and social connection on cognitive function were no longer statistically significant, while high intensity of physical activities became significantly associated with cognitive function and the association between social activity and cognitive function was only significant at the marginal level. Therefore, comparing with the older adults who spent no time on physical activity, those participants who engaged in physical activity with high intensity (more than average) maintained better cognitive function. Model 4 explained 45 per cent of the total variance of cognitive function and about 0.61 per cent was explained by physical activity effect.

Table 4 shows the association between different types of leisure activities and subsequent cognitive function among older men. In Model 1, higher intensity of sedentary sitting and social connecting was negatively associated with worse cognitive function, whereas even lower intensity of cognitive activities has a protective effect on cognitive function. However, in Model 2, the negative impacts of sedentary sitting and social connection were no longer significant after controlling socio-demographic characteristics. The positive impact of cognitive activity on cognitive function maintained significance and physical activity became significantly associated with cognitive function. In Models 3 and 4, cognitive activities and physical activities were still positively associated with subsequent cognitive function, suggesting that engaging in cognitive activities and physical activities, especially with high intensity, reduced the risk of cognitive decline among older men. Model 4 explained 40 per cent of the total variance of older men's cognitive function and about 1.26 and 1.68 per cent were explained by cognitive activities and physical activities, respectively.

Table 5 shows the associations between leisure activities in 2015 and cognitive function in 2018 among older women. In Model 1, only sedentary sitting and cognitive activity were significantly associated with subsequent cognitive function. However, in Models 2 and 3, after controlling socio-demographic characteristics of participants and health conditions step by step, only social connecting (lower than average) was significantly associated with cognitive function at the marginal level. In Model 4, when adding baseline cognitive function, none of the leisure activities were significantly associated with cognitive function, indicating that leisure activities had no direct impact on older women's cognitive function in rural

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Table 3. Ordinary least-squares regression results for cognitive function in 2018 among the whole sample

Variables	Model 1	Model 2	Model 3	Model 4
		B values (95% confidence intervals)		
Sedentary sitting (Ref. None):				
Less than average	−0.27 (−0.75, 0.20)	−0.10 (−0.49, 0.30)	−0.10 (−0.49, 0.29)	−0.19 (−0.56, 0.18)
More than average	−1.36 (−1.90, −0.83)***	−0.31 (−0.78, 0.16)	−0.14 (−0.60, 0.33)	−0.20 (−0.64, 0.25)
Cognitive activity (Ref. None):				
Less than average	1.00 (0.59, 1.41)***	0.33 (−0.01, 0.68)†	0.25 (−0.09, 0.59)	0.08 (−0.25, 0.41)
More than average	0.99 (0.53, 1.44)***	0.60 (0.22, 0.98)**	0.46 (0.09, 0.84)*	0.24 (−0.13, 0.60)
Physical activity (Ref. None):				
Less than average	0.13 (−0.28, 0.54)	0.31 (−0.04, 0.66)†	0.31 (−0.04, 0.66)†	0.26 (−0.07, 0.59)
More than average	−0.05 (−0.54, 0.43)	0.47 (0.04, 0.90)*	0.48 (0.06, 0.90)*	0.47 (0.06, 0.87)*
Social connection (Ref. None):				
Less than average	−0.08 (−0.48, 0.32)	0.02 (−0.31, 0.35)	0.05 (−0.27, 0.37)	0.02 (−0.29, 0.33)
More than average	−0.60 (−1.02, −0.17)**	0.05 (−0.32, 0.42)	−0.05 (−0.41, 0.32)	−0.19 (−0.53, 0.16)
Social activity (Ref. None):				
Less than average	1.25 (0.04, 2.45)*	0.96 (−0.04, 1.96)†	0.97 (−0.01, 1.96)†	0.93 (−0.02, 1.87)†
More than average	0.55 (−1.19, 2.30)	0.51 (−0.94, 1.96)	0.45 (−0.98, 1.88)	0.17 (−1.20, 1.54)
Gender		1.37 (1.04, 1.69)***	1.24 (0.92, 1.57)***	0.86 (0.55, 1.18)***
Age in 2015		−0.10 (−0.12, −0.08)***	−0.09 (−0.11, −0.06)***	−0.06 (−0.08, −0.04)***
Marital status in 2015 (Ref. Single)		0.70 (0.25, 1.14)**	0.66 (0.22, 1.10)**	0.52 (0.10, 0.94)*
Education (Ref. Illiterate)		1.25 (0.93, 1.56)***	1.26 (0.95, 1.56)***	0.89 (0.59, 1.20)***

Annual income in 2015		0.12 (0.01, 0.22)*	0.08 (−0.02, 0.19)	0.06 (−0.04, 0.16)
Time for economic work in 2015		0.09 (0.02, 0.15)**	0.05 (−0.02, 0.11)	0.05 (−0.01, 0.11)†
Time for housework in 2015		0.09 (0.02, 0.17)*	0.05 (−0.03, 0.12)	0.03 (−0.04, 0.10)
Living alone in 2015		0.53 (0.08, 0.99)*	0.41 (−0.04, 0.86)†	0.37 (−0.06, 0.80)†
Diabetes in 2015			0.30 (−0.18, 0.78)	0.25 (−0.21, 0.71)
Hypertension in 2015			−0.01 (−0.30, 0.27)	0.01 (−0.26, 0.28)
Cardiovascular disease in 2015			0.38 (0.04, 0.73)*	0.40 (0.07, 0.73)*
ADLs in 2015			0.09 (0.06, 0.12)***	0.05 (0.02, 0.08)***
Cognition in 2015				0.33 (0.26, 0.39)***
Constant	6.97 (6.44, 7.49)***	10.23 (8.30, 12.16)***	6.36 (4.03, 8.69)***	4.57 (2.32, 6.82)***
F (p)	7.73 (<0.001)	33.15 (<0.001)	29.46 (<0.001)	35.06 (<0.001)
R^2	0.07	0.37	0.39	0.45

Notes: N = 1,018. Ref.: reference category. ADLs: activities of daily living.
Significance levels: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4. Ordinary least-squares regression results for cognitive function in 2018 among older men

Variables	Model 1	Model 2	Model 3	Model 4
		B values (95% confidence intervals)		
Sedentary sitting (Ref. None):				
Less than average	−0.24 (−0.82, 0.33)	0.01 (−0.50, 0.51)	−0.02 (−0.51, 0.48)	−0.03 (−0.50, 0.45)
More than average	−1.27 (−1.92, −0.61)***	−0.44 (−1.04, 0.15)	−0.26 (−0.85, 0.33)	−0.27 (−0.84, 0.30)
Cognitive activity (Ref. None):				
Less than average	1.01 (0.50, 1.52)***	0.69 (0.23, 1.14)**	0.61 (0.16, 1.06)**	0.40 (−0.04, 0.84)†
More than average	1.08 (0.53, 1.64)***	1.08 (0.58, 1.57)***	0.94 (0.45, 1.43)***	0.61 (0.13, 1.10)*
Physical activity (Ref. None):				
Less than average	0.30 (−0.17, 0.77)	0.53 (0.11, 0.96)*	0.50 (0.08, 0.92)*	0.44 (0.04, 0.85)*
More than average	−0.29 (−0.84, 0.26)	0.69 (0.16, 1.21)*	0.69 (0.18, 1.21)**	0.63 (0.13, 1.13)*
Social connection (Ref. None):				
Less than average	−0.28 (−0.74, 0.19)	−0.33 (−0.75, 0.08)	−0.27 (−0.67, 0.13)	−0.27 (−0.66, 0.12)
More than average	−0.59 (−1.11, −0.08)*	−0.14 (−0.61, 0.33)	−0.23 (−0.70, 0.23)	−0.40 (−0.85, 0.05)
Social activity (Ref. None):				
Less than average	1.08 (−0.32, 2.48)	0.97 (−0.27, 2.20)	1.11 (−0.10, 2.32)†	0.93 (−0.23, 2.09)
More than average	0.01 (−1.96, 1.97)	−0.49 (−2.24, 1.26)	−0.82 (−2.53, 0.90)	−0.63 (−2.28, 1.02)
Age in 2015		−0.10 (−0.12, −0.07)***	−0.09 (−0.11, −0.06)***	−0.07 (−0.09, −0.04)***
Marital status in 2015 (Ref. Single)		0.58 (0.01, 1.15)*	0.59 (0.03, 1.15)*	0.40 (−0.14, 0.94)
Education (Ref. Illiterate)		1.12 (0.77, 1.48)***	1.07 (0.73, 1.42)***	0.82 (0.48, 1.16)***
Annual income in 2015		0.10 (−0.02, 0.22)	0.04 (−0.08, 0.16)	0.04 (−0.08, 0.16)

Time for economic work in 2015		0.12 (0.04, 0.20)**	0.07 (−0.08, 0.16)†	0.05 (−0.03, 0.13)
Time for housework in 2015		0.11 (0.03, 0.19)**	0.07 (−0.01, 0.15)†	0.04 (−0.04, 0.12)
Living alone in 2015		0.60 (0.01, 1.18)*	0.51 (−0.06, 1.08)†	0.48 (−0.06, 1.03)†
Diabetes in 2015			−0.11 (−0.79, 0.57)	−0.08 (−0.73, 0.58)
Hypertension in 2015			0.14 (−0.22, 0.50)	0.10 (−0.25, 0.44)
Cardiovascular disease in 2015			0.26 (−0.21, 0.72)	0.36 (−0.09, 0.80)
ADLs in 2015			0.11 (0.07, 0.15)***	0.07 (0.03, 0.11)***
Cognition in 2015				0.32 (0.22, 0.41)***
Constant	7.90 (7.25, 8.56)***	11.30 (8.84, 13.77)***	6.88 (3.97, 9.78)***	4.89 (2.05, 7.74)**
F (p)	5.32 (<0.001)	13.46 (<0.001)	12.82 (<0.001)	15.13 (<0.001)
R^2	0.10	0.31	0.35	0.40

Notes: N = 518. Ref.: reference category. ADLs: activities of daily living.
Significance levels: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5. Ordinary least-squares regression results for cognitive function in 2018 among older women

Variables	Model 1	Model 2	Model 3	Model 4
		B values (95% confidence intervals)		
Sedentary sitting (Ref. None):				
Less than average	−0.53 (−1.20, 0.14)	−0.25 (−0.85, 0.36)	−0.23 (−0.83, 0.37)	−0.37 (−0.95, 0.20)
More than average	−1.44 (−2.19, −0.70)***	−0.24 (−0.96, 0.48)	−0.06 (−0.78, 0.66)	−0.14 (−0.83, 0.56)
Cognitive activity (Ref. None):				
Less than average	0.65 (0.08, 1.22)*	−0.01 (−0.53, 0.52)	−0.04 (−0.56, 0.48)	−0.18 (−0.69, 0.32)
More than average	0.49 (−0.16, 1.13)	0.09 (−0.50, 0.68)	−0.01 (−0.59, 0.58)	−0.14 (−0.70, 0.42)
Physical activity (Ref. None):				
Less than average	−0.37 (−0.99, 0.24)	0.10 (−0.46, 0.66)	0.10 (−0.46, 0.66)	0.06 (−0.48, 0.60)
More than average	−0.18 (−0.93, 0.56)	0.26 (−0.45, 0.96)	0.24 (−0.46, 0.94)	0.28 (−0.39, 0.95)
Social connection (Ref. None):				
Less than average	0.33 (−0.25, 0.91)	0.48 (−0.05, 1.00)†	0.48 (−0.04, 0.99)†	0.40 (−0.10, 0.89)
More than average	−0.20 (−0.80, 0.40)	0.31 (−0.25, 0.87)	0.21 (−0.35, 0.77)	0.10 (−0.44, 0.64)
Social activity (Ref. None):				
Less than average	1.34 (−0.44, 3.12)	1.03 (−0.57, 2.62)	0.96 (−0.62, 2.54)	1.07 (−0.45, 2.58)
More than average	0.99 (−1.68, 3.66)	1.79 (−0.61, 4.19)	1.83 (−0.55, 4.20)	1.01 (−1.28, 3.30)
Age in 2015		−0.11 (−0.14, −0.08)***	−0.09 (−0.12, −0.06)***	−0.07 (−0.10, −0.03)***
Marital status in 2015 (Ref. Single)		0.74 (0.04, 1.44)*	0.71 (0.01, 1.40)*	0.62 (−0.04, 1.29)†
Education (Ref. Illiterate)		1.52 (0.94, 2.10)***	1.54 (0.96, 2.11***	1.04 (0.47, 1.61)***
Annual income in 2015		0.11 (−0.08, 0.30)	0.09 (−0.10, 0.27)	0.05 (−0.13, 0.23)

Time for economic work in 2015		0.06 (−0.03, 0.16)	0.03 (−0.06, 0.13)	0.06 (−0.03, 0.16)
Time for housework in 2015		0.07 (−0.07, 0.21)	0.01 (−0.14, 0.15)	0.01 (−0.13, 0.14)
Living alone in 2015		0.37 (−0.33, 1.08)	0.19 (−0.52, 0.89)	0.14 (−0.53, 0.82)
Diabetes in 2015			0.45 (−0.24, 1.15)	0.39 (−0.28, 1.05)
Hypertension in 2015			−0.07 (−0.52, 0.38)	−0.01 (−0.45, 0.42)
Cardiovascular disease in 2015			0.56 (0.05, 1.07)*	0.52 (0.03, 1.01)*
ADLs in 2015			0.08 (0.03, 0.12)**	0.05 (−0.01, 0.09)†
Cognition in 2015				0.31 (0.22, 0.41)***
Constant	6.35 (5.62, 7.08)	11.34 (8.19, 14.50)***	7.55 (3.70, 11.40)***	5.56 (1.82, 9.29)***
F (p)	2.81 (<0.001)	10.00 (<0.001)	8.97 (<0.001)	11.31 (<0.001)
R^2	0.05	0.26	0.28	0.34

Notes: N = 500. Ref.: reference category. ADLs: activities of daily living.
Significance levels: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

China. Thirty-four per cent of the total variance of older women's cognitive function was explained by Model 4.

A gender difference test for the associations between leisure-time activities and cognitive function after controlling confounders and cognitive function at baseline were conducted (detailed results are not provided here but can be provided upon request). Results confirmed that there are significant gender differences in the effects of cognitive activities (t_1 =1.82, $p = 0.07$; $t_2 = 2.06$, $p = 0.04$) and low intensity of social connecting activities ($t_1 = -2.15$, $p = 0.03$) on cognitive function.

Discussion

Based on data from two waves of a longitudinal survey in rural China, this study examined the impacts of different kinds of leisure activities on cognitive function three years later among older adults aged 60 and older. To our knowledge, this was one of only a few studies that divided leisure activities based on both social (or solitary) and active (or sedentary) dimensions, and compared their independent effects on cognitive function in China. Our study showed that active cognitive and physical activity was associated with better cognitive function after the adjustment of socio-economic status and health condition at baseline and mutual adjustment of leisure activities, however, these associations were more pronounced among older men. Our findings extended beyond previous knowledge that the benefits of leisure activities on the health of older adults varies by types and social context; it especially extends beyond previous understanding that even activities like watching TV, which lack social or physical components, can still benefit older adults' functionality by improving their psycho-social function (O'Neill and Dogra, 2016).

In our study, the positive effect of engaging in cognitive activities was significant among older men, which partly supports the findings from a previous study showing that cognitive activities, such as watching TV, listening to the radio, or reading books or newspapers, was associated with lower risk of cognitive impairment among Chinese older adults in later life (Mao *et al.*, 2020). In our sample, the majority of participants have a very low level of education, which may limit their ability to participate in other cognitive activities, such as reading books or newspapers. Previous studies also suggest that Chinese older adults spent the greatest amount of time watching TV in their leisure time (Su *et al.*, 2006). Our finding provides further evidence that watching TV may serve as a major cognitively stimulative activity for Chinese older adults (Mao *et al.*, 2020). One possible reason is that watching TV in rural China is a major source of information acquisition. Watching TV was found to be a risk factor for cognitive impairment or dementia in Western countries (Akbaraly *et al.*, 2009; Hamer and Stamatakis, 2014). These discrepancies in findings may be partially explained by the differences in sample characteristics and level of socio-economic development in the region. Our finding suggests that future studies on classification of leisure activities need to take the local context into consideration.

The present study found that engaging in physical activity, especially with high intensity (above average), was significantly associated with better cognitive function in follow-up after adjustment of socio-economic status and health condition at baseline and mutual adjustment of leisure activities. Our results were fairly

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consistent with those of previous studies which found that high physical activity provides a protective effect against cognitive impairment by promoting healthy brain ageing and reducing neurodegenerative disease risk (Etgen *et al.*, 2010; Buchman *et al.*, 2012; Livingston *et al.*, 2017). However, different from previous findings that physical activity was not associated with cognitive decline when participation in cognitively stimulating activities were taken into account (Verghese *et al.*, 2003; Sturman *et al.*, 2005), our result confirmed that the beneficial effect of physical activity on cognition was independent of other leisure activities, including cognitively stimulating activity, in rural China. Our findings suggest that high physical activity was more protective against cognitive decline than other leisure activities among older adults in rural China.

Our study also extends understanding of the gender difference in leisure activities and the gender-specific effects of leisure activities on cognitive function. In this study, the time allocation in leisure activities showed a gender-specific pattern. Older women spent more time on sedentary sitting, while older men spent more time on physical and cognitive activities. There was no gender difference for the time-use in social connection and social activities. These results confirmed previous findings that men are more physically active than women in leisure time (Burton and Turrell, 2000; Schnohr *et al.*, 2003; Azevedo *et al.*, 2007). Moreover, there were gender differences in the association between leisure activities and cognitive function. High cognitive activity was only significantly associated with older men's cognitive capacity rather than that of older women. According to the complex environmental hypothesis, gendered patterns of leisure activities may contribute to gender difference in the association between leisure activities and cognitive function. Old women spent more time on household chores, leading to limited variations in leisure activities and fewer cognitive demands in daily activities in general, and less time to participate in cognitive activities, which in this study was found to have a protect effect among older men (Hassing, 2020). Therefore, our findings confirmed that the gendered pattern of time-use contributed to the gender differences in the association between cognitive activities and cognitive function.

Limitations

Several limitations of this study should be noted. Primarily, data for daily diary time-use were available only in the most recent two waves. Inclusion of more waves of observation will allow more diversified analysis into cognitive decline trajectories and their causal relationships with leisure activities. It has been suggested that leisure activities and functionality have reciprocal effects (Schooler and Mulatu, 2001; Aartsen *et al.*, 2002). Although we included three incidences of chronic diseases, ADLs and cognition in the model for the purpose of controlling for physical health at the initial stage, the possible reverse causation could not be fully ruled out. A second limitation stems from the fact that our data come from a well-defined area of central China, which is thought to typify the social and cultural conditions of poor rural areas. The rural older people had lower levels of literacy and worse health conditions than those in urban areas of China, which may limit the generalisability of the results to other populations. A third possible limitation is related to the self-reported leisure activities. Though a comprehensive 24-hour recall measure allowed

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us to collect more precise and accurate information of daily activities, the self-reported diary still cannot exclude the potential for over- or under-estimation of time allocation of different leisure activities. Overall means were used as reference in defining the cut-off points for the intensity of leisure activities in this study which may also restrict comparison with other studies. Finally, because we only collected the time-use for a single day per participant, it is not possible to examine the within-person variation in time over the course of a week or season. Future studies should devote more efforts to collecting week-long diaries to overcome the single-day limitation.

Conclusion

In conclusion, as the population is ageing and life expectancy is increasing, to identify how cognitive decline may be delayed or reduced has important implications for ageing well. Our study confirmed that older people's cognitive function can benefit mostly from high physical activity in rural China; and the beneficial effect of cognitive activity on cognitive function is only significant among older men. These findings have important theoretical and public health implications. When using the 'use it or lose it' hypothesis of cognitive ageing to explain the relationship between leisure activities and cognitive function, it is important to consider individual characteristics and social context. Moreover, our study highlights the need to consider gender differences in the relationship between leisure activities and cognitive function. It is important to consider gender-specific intervention in leisure activities to maintain cognitive function among older adults. In addition, there is a great need to develop more community-based activities and programmes tailored to the needs of the ageing population in rural China.

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Author contributions.
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