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The impact of physical and mind exercise on functional disability in activities of daily living among the oldest old

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Abstract

Objective In an aging society, it is essential for older adults to maintain their ability for independent daily living. This study investigates the effects of physical and mind exercise on functional impairment in activities of daily living among older adults aged 80 years and older.

Methods Data were sourced from the CLHLS database for the years 1998, 2000, 2002, 2005, 2008, and 2018, with a final sample of 62,581 respondents included in the analysis. Binary logistic regression models were employed for data analysis.

Results Our analysis suggests that the oldest-old adults engaging in physical exercise have an approximately 44.9% lower probability of ADL disability than those not exercising (95%CI: 0.509, 0.596), whereas those engaging in mind exercise have an approximately 40.4% lower probability (95%CI: 0.537, 0.661). when the oldest-old engage in both physical and mind exercise, their risk of ADL disability is reduced by 53.6% (95%CI: 0.399, 0.538).

Conclusion In addition to encouraging the oldest-old to engage in appropriate physical exercise, promoting simultaneous engagement in mind exercises is important. This approach is more beneficial for sustaining older adults' health and contributes to healthy aging.

Keywords Physical exercise, Mind exercise, ADL, Older adults

Introduction

Activities of daily living (ADL) refer to the essential activities a person performs daily to meet their basic needs, including eating, dressing, getting in or out of bed or a chair, bathing, and using the toilet [1]. ADL disability describes difficulties or an inability to perform these daily activities. The oldest individuals are particularly vulnerable to ADL disabilities [2]. Research indicates that ADL disabilities can lead to a range of problems for older adults [3–5], such as an increased risk of cardiovascular diseases; mood disorders such as depression and anxiety; reduced quality of life; and increased risks of outpatient care, hospitalization, nursing home admission, and mortality. These challenges may impose a significant financial

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burden on both families and society. With the rapid aging of the global population, the number of oldest individuals is on the rise [6], highlighting the critical public health and social issues associated with ADL disabilities in this population.

For many years, physical exercise has been recognized as an important way to promote health among the oldest old [7–9]. Studies have shown that physical exercise for the oldest old not only has positive effects on the risk of diseases such as diabetes [10], depression [11], cognitive decline [12], and mortality [13] but also improves objective measures of physical function, such as aerobic capacity, walking speed, muscle strength, and balance [11, 14–17]. These findings suggest that engaging in physical exercise positively impacts the health of the oldest old individuals and may enhance their ability to perform physical activities. While numerous studies have investigated the effects of physical exercise on ADLs, a literature review reveals a paucity of research specifically examining the relationship between physical activity and ADL disability among the oldest-old (aged 80 years and above). Existing studies have focused predominantly on younger older adult populations (60–75 years). Furthermore, most prior research on physical activity in the oldest-old has been conducted among European and American populations, with limited evidence available from older Chinese adult cohorts. Therefore, supplementing research evidence on the association between physical exercise participation and ADL disability among China's oldest-old population would significantly enhance our understanding of this relationship in advanced age groups. These findings could provide valuable insights for developing targeted health interventions for the oldest-old population in future practice.

Additionally, mind exercises refer to games based primarily on intellectual rather than physical skills [18], including playing cards or mahjong [19], which have therapeutic effects on cognitive function in older people [20]. It refers to activities that engage cognitive functions through intellectual games, brain-training toys, and similar tools that stimulate the brain, promote neural connectivity, and enhance attention, memory, and problem-solving skills [21–24]. A study showed that older adults who play cards/mahjong more frequently are also significantly more likely to be involved in physical exercise than those who do not play cards/mahjong or play less frequently [25]. One may question this choice of exercise, arguing that mind exercises are merely sedentary exercises, which, as part of sedentary lifestyles, have contributed to the worsening of population health and led to adverse health outcomes [26, 27]. However, sedentary activities that keep the mind engaged have also been praised in similar contexts [28]. The impact of mind exercises on the ADL in the oldest-old population is highly important. On the one hand, with the increasing global aging population, maintaining independent living abilities in the oldest-old has become a critical challenge in public health. ADL, as a core indicator for assessing functional independence in older adults, directly affects their quality of life, care needs, and socioeconomic burden. Investigating the influence of mind exercises on ADLs in the oldest-old may help uncover the complex cognitive–motor interaction mechanisms underlying ADL-related issues in aging populations. From a neuroscientific perspective, although brain plasticity declines with advanced age, recent studies suggest that older adults may still maintain motor executive function through targeted cognitive training by activating compensatory neural networks or slowing neurodegenerative processes [29]. For example, attention training may enhance sensorimotor integration efficiency, reducing the risk of critical ADL-related events such as falls. Thus, exploring the relationship between mind exercises and ADLs in older adults provides a crucial window into the applicability of the cognitive reserve theory in extreme-age populations. Finally, mind exercises represent a low-cost, low-barrier intervention. If research confirms their positive relationship with ADLs, it could facilitate the development of more cost-effective ADL intervention models, promoting health equity. However, research on whether mind exercises impact ADL abilities in the oldest old remains relatively limited, necessitating further exploration.

Therefore, this study aims to examine the relationships among physical exercise, mind exercises, and ADL disabilities among the oldest individuals in China, using the most representative Chinese longitudinal data from 1998 to 2018. Moreover, we investigated the relationships between different combinations of physical and mind exercises and ADL disability in this population.

Methods

Data sources

The data were extracted from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), which is a national longitudinal survey of older Chinese adults. The CLHLS started in 1998 and accomplished a total of eight waves in 1998, 2000, 2002, 2005, 2008/2009, 2011/2012, 2014, and 2018/2019. More details about the survey were published in the literature [30]. The present study used the most recent wave in the years 1998, 2000, 2002, 2005, 2008/2009, and 2018/2019. The data from the 2011/2012 and 2014 waves were not used because these waves surveyed only older adults who were alive in 2008 and did not include newly added samples.

The study selected participants aged 80 years or older who had fully completed both the physical and mind exercise program and the ADL assessments. The study excluded samples with substantial missing values for

key research variables as well as those from participants aged younger than 80 years. The final analytical dataset included 62,581 respondents. The dataset included 25,172 males (40.22%) and 37,409 females (59.78%). Age stratification revealed 47,034 octogenarians to centenarians (80–100 years, 75.16%) and 15,547 semi-supercentenarians (≥ 100 years, 24.84%).

All participants involved in the survey consented to take part in the survey, including answering the ADL items. Written informed consent was obtained from all participants and/or their proxy respondents, and the study was approved by the Research Ethics Committee of Peking University (IRB00001052–13074).

Measures

The CLHLS uses data on activities of daily living (ADL) to assess disability at the time of the survey and is based on the Katz ADL scale [31]. The six ADL items evaluate whether respondents have difficulty with bathing, dressing, indoor transferring, toileting, eating, and continence. Respondents unable to perform all six activities independently are classified as having an ADL disability and assigned a value of 1, whereas all others are assigned a value of 0. Physical and mind exercise were measured via the following questions: "Do you currently exercise regularly?" (0 = No, 1 = Yes) and "Do you currently play cards or mahjong?" (0 = No, 1 = Yes).

The control variables included age, sex (0 = male, 1 = female), household registration (0 = rural, 1 = urban), living arrangement (0 = nonliving alone, 1 = living alone), education level (0 = literate, 1 = illiterate), marital status (0 = widowed/unmarried/divorced, 1 = married), current smoking status (0 = No, 1 = Yes), current drinking status (0 = No, 1 = Yes), and pension status (0 = No, 1 = Yes). The MMSE inventory contains 24 items [32]. These items comprise the components used to measure orientation, registration, calculation, recall and language. The usual practice of CLHLS users tended to sum these items for a score ranging from 0 to 30. The CLHLS employs the Center for Epidemiologic Studies Depression Scale (CES-D) to assess depressive symptoms among older individuals [33], with a score ranging from 3 to 24 points.

Statistical analysis

Statistical analyses were conducted via Stata 15.0. We employed binary logistic regression models to examine the relationship between physical and mental exercise and ADL disability, controlling for both individual and time fixed effects to increase estimation accuracy. When analyzing the relationships between physical and mind exercises and ADLs, our study first analyzed only the relationships between physical exercise and ADLs to form Model (1) We subsequently analyzed the relationship between mind exercise and ADLs to form Model (2) Finally, we included both physical and mind exercises in the model simultaneously to form Model (3) To analyze the relationships between different exercise patterns and ADLs, our study first analyzed the relationships between the exclusive physical exercise pattern and ADLs to form Model (4) Next, we analyzed the relationship between the exclusive mind exercise pattern and ADLs to form Model (5) Finally, we analyzed the relationships between the combined physical and mind exercise patterns and ADLs to form Model 6.

Results

Describe the characteristics of the respondents

Table 1 presents the demographic characteristics of the participants. The results indicate that 47,034 older adults (75.16%) were aged between 80 and 100 years, while 15,547 participants (11.73%) were aged 100 years or older. A total of 32,628 individuals (52.14%) resided in rural areas, and 29,953 (47.86%) lived in urban settings; among them, 8,753 older adults (14.02%) lived alone. Additionally, the data revealed that 22,002 participants (35.16%) had ADL disabilities, 16,788 (26.83%) engaged in physical exercise, and 7,339 (11.73%) participated in mind exercise.

Associations between two types of exercise and ADL disability

Table 2 presents the results of the logistic regression analysis examining the associations between physical and mind exercise and ADL disability. After controlling for variables such as age, sex, health behaviors and living arrangements, the results of Model 1 indicate that the oldest-old adults currently engaging in physical exercise have an approximately 46.6% lower probability of ADL disability than those not exercising (95%CI: 0.494, 0.579). Similarly, Model 2 shows that the oldest-old adults currently engaging in mind exercise have an approximately 44.1% lower probability of ADL disability than non-mind exercisers do (95%CI: 0.504, 0.621). Both physical and mind exercise were included in Model 3 for further analysis. The results of Model 3 reveal that the oldest-old adults engaging in physical exercise have an approximately 44.9% lower probability of ADL disability than those not exercising (95%CI: 0.509, 0.596), whereas those engaging in mind exercise have an approximately 40.4% lower probability (95%CI: 0.537, 0.661). Thus, both physical and mind exercise reduce the risk of ADL disability among the oldest-old, and the risk reduction effect of physical exercise is stronger.

Associations between different exercise modes and ADL disability

To further reveal the impact of physical exercise and mind exercise on ADL disability among the oldest-old

Table 1 Respondent characteristics

Variable	*n* (%)/M ± SD	Variable	*n* (%)/M ± SD
ADL disability		Education status	
no	40,579(64.84)	literate	21,799(34.83)
yes	22,002(35.16)	illiterate	40,782(65.17)
Physical exercise		Region	
no	45,793(73.17)	rural	32,628(52.14)
yes	16,788(26.83)	urban	29,953(47.86)
Mind exercise		Live alone	
no	55,242(88.27)	no	53,699(85.98)
yes	7,339(11.73)	yes	8,753(14.02)
Age		Pension	
80 ~ 100	47,034(75.16)	no	51,866(83.23)
≥100	15,547(24.84)	yes	10,452(16.77)
Gender		Smoking	
male	25,172(40.22)	no	51,295(82.16)
female	37,409(59.78)	yes	11,140(17.84)
Marital status		Drinking	
widowed/unmarried/divorced	51,167(81.89)	no	53,141(85.05)
married	11,313(18.11)	yes	9,339(14.95)
MMSE [0–30]	18.84 ± 8.56	Depression [3–24]	10.68 ± 2.44

SD: standard deviation; M: mean

Table 2 Associations between physical and Mind exercise and ADL disability

Variables	Model 1			Model 2			Model 3		
	OR	SE	95% CI	OR	SE	95% CI	OR	SE	95% CI
Physical exercise (1 = yes)	0.534	0.021	0.494, 0.579	-	-	-	0.551	0.022	0.509, 0.596
Mind exercise (1 = yes)	-	-	-	0.559	0.030	0.504, 0.621	0.596	0.032	0.537, 0.661
Age (1 = 100 years and older)	2.880	0.137	2.624, 3.162	2.876	0.136	2.621, 3.156	2.848	0.135	2.595, 3.126
Gender (1 = male)	1.103	0.046	1.017, 1.196	1.138	0.047	1.049, 1.234	1.106	0.046	1.019, 1.200
Marital status (1 = married)	0.540	0.027	0.490, 0.594	0.543	0.027	0.494, 0.598	0.542	0.027	0.492, 0.596
Education status (1 = literacy)	0.893	0.037	0.824, 0.968	0.898	0.037	0.829, 0.973	0.875	0.036	0.807, 0.949
Region (1 = urban)	1.828	0.068	1.700, 1.966	1.779	0.066	1.655, 1.912	1.848	0.069	1.718, 1.988
Live alone (1 = yes)	0.256	0.016	0.227, 0.288	0.257	0.016	0.228, 0.289	0.255	0.016	0.227, 0.288
Pension (1 = yes)	1.876	0.095	1.698, 2.071	1.749	0.087	1.586, 1.928	1.919	0.098	1.736, 2.120
Drinking (1 = yes)	0.750	0.033	0.687, 0.819	0.742	0.033	0.680, 0.811	0.758	0.034	0.694, 0.827
Smoking (1 = yes)	0.742	0.037	0.673, 0.819	0.755	0.038	0.685, 0.833	0.766	0.038	0.695, 0.845
MMSE [0–30]	0.893	0.003	0.887, 0.900	0.892	0.003	0.885, 0.898	0.895	0.003	0.889, 0.902
Depression [3–24]	0.926	0.006	0.914, 0.939	0.920	0.006	0.908, 0.933	0.929	0.006	0.916, 0.941

in real-world scenarios, we considered three modes. The first mode includes only physical exercise; the second mode includes only mind exercise; and the third mode includes both physical and mind exercise simultaneously. The model results are presented in Table 3. The findings indicate that when the oldest-old engage only in physical exercise, their risk of ADL disability is reduced by 36.4% (95%CI: 0.588, 0.689). When they engage only in mind exercise, the effect on reducing ADL disability risk is not significant (95%CI: 0.634, 0.823). However, when the oldest-old engage in both physical and mind exercise, their risk of ADL disability is reduced by 53.6% (95%CI: 0.399, 0.538). These results suggest that physical exercise is a critical factor in reducing ADL disability among the oldest-old. Furthermore, the combination of physical and mind exercise has an even more pronounced effect on lowering the risk of ADL disability in this population.

Discussion

With the accelerated process of global population aging, maintaining the independent living ability of older adults has emerged as a pivotal challenge in public health. This study aims to explore the relationships between physical and cognitive exercise, as well as various combinations of these exercises, and ADL disability among individuals aged 80 years and above. Our study revealed that engaging in physical or mind exercise may be negatively correlated with ADL disability among the oldest individuals. This conclusion aligns with previous findings on the benefits of physical exercise and mind exercises [11].

Table 3 Associations between exercise mode and ADL disability

Variables	Mode 4: Only physical exercise			Mode 5: Only mind exercise			Mode 6: Physical and mind exercise		
	OR	SE	95% CI	OR	SE	95% CI	OR	SE	95% CI
Exercise mode	0.636	0.026	0.588, 0.689	0.723	0.048	0.634, 0.823	0.464	0.035	0.399, 0.538
Age (1 = 100 years and older)	2.891	0.137	2.634, 3.173	2.899	0.138	2.641, 3.181	2.901	0.138	2.264, 3.184
Gender (1 = male)	1.137	0.047	1.048, 1.233	1.136	0.047	1.047, 1.231	1.111	0.046	1.024, 1.205
Marital status (1 = married)	0.544	0.027	0.494, 0.599	0.542	0.026	0.492, 0.596	0.539	0.026	0.490, 0.593
Education status (1 = literacy)	0.903	0.037	0.833, 0.978	0.916	0.037	0.845, 0.992	0.911	0.037	0.841, 0.987
Region (1 = urban)	1.779	0.066	1.655, 1.912	1.755	0.064	1.634, 1.886	1.789	0.066	1.665, 1.924
Live alone (1 = yes)	0.257	0.016	0.228, 0.290	0.258	0.016	0.229, 0.290	0.257	0.016	0.228, 0.290
Pension (1 = yes)	1.772	0.089	1.607, 1.955	1.691	0.083	1.535, 1.862	1.770	0.088	1.606, 1.952
Drinking (1 = yes)	0.744	0.033	0.681, 0.812	0.734	0.037	0.670, 0.814	0.739	0.033	0.677, 0.806
Smoking (1 = yes)	0.740	0.037	0.671, 0.815	0.739	0.037	0.670, 0.814	0.732	0.036	0.664, 0.807
MMSE [0–30]	0.891	0.003	0.884, 0.897	0.890	0.003	0.883, 0.896	0.891	0.003	0.884, 0.897
Depression [3–24]	0.920	0.006	0.908, 0.933	0.917	0.006	0.905, 0.930	0.922	0.006	0.909, 0.934

The use and disuse theory posits that biological systems maintain or atrophy functions through patterns of utilization, analogous to mechanical systems where regular exercise preserves physiological homeostasis [34]. Thus, physical and mind exercises help the oldest old maintain a relatively active and healthy physical and mental state, thereby reducing the risk of ADL disability. Additionally, past studies have shown that physical exercise can mitigate or slow the functional decline associated with aging, improve gait, reduce fall rates, enhance functional capacity [35], improve grip strength [10], and prevent sarcopenia [36]. It also enhances leg muscle strength, thereby lowering fall risk [14]. On the other hand, mind exercise is essential for improving cognitive function in older adults. Good cognitive abilities help individuals better understand and perform ADL tasks, such as following complex instructions and remembering the steps of daily routines. Many ADL activities, such as laundry or cooking, require not only physical coordination but also cognitive skills to plan and execute tasks. Therefore, mind exercises may help lower the risk of ADL disability by assisting individuals in performing daily activities more effectively. For example, research has shown that mind exercises (e.g., playing cards or mahjong) can lower the risk of disability among the oldest old [37].

Our study revealed that, among the oldest individuals, engaging solely in physical exercise may have a more significant negative relationship with ADL disability than participating solely in mind exercises. Our study revealed that, among the oldest individuals, participating only in physical exercise has a more significant effect on reducing the risk of ADL disability than does participating only in mind exercises. Research shows that older adults tend to become increasingly sedentary over time [38], with China's oldest old population also becoming more sedentary between 1998 and 2018 [39]. Mind exercises may increase the risk of prolonged sedentary behavior, which, in turn, could increase the risk of ADL disability. Data from the United States indicate a strong association between increased sedentary time and ADL disability [40]. Among the oldest individuals, physical exercise can help counter a sedentary lifestyle to some extent, promoting improvements in both health and quality of life [39].

Our study also revealed that engaging in both physical and mind exercises simultaneously may have the most significant negative relationship with ADL disability among the oldest individuals. This may be because combining physical and mind exercises helps maximize overall physical and mental health. For the oldest old, physical exercise directly reduces ADL disability risk by promoting physical health, particularly by mitigating age-related decline, improving gait, reducing fall rates, and enhancing functional capacity [35]. Meanwhile, mind exercise indirectly reduces ADL disability risk by supporting cognitive health. By increasing brain activity, such as through continuous memory and calculation tasks [22, 41], they enhance social engagement and improve verbal fluency, calculation abilities, and memory [42, 43]. Therefore, when the oldest individuals engage in both physical and mind exercises, the combined health benefits significantly reduce the risk of ADL disability.

Finally, our study indicates that older individuals can exercise and that age should not be a barrier to physical activity; exercise has proven health benefits for the oldest individuals [44]. In China, however, the oldest individuals are becoming more sedentary, with the likelihood of engaging in physical exercise declining by 24% and the likelihood of men engaging in mind exercises decreasing by approximately 30% [39]. Research shows that the proportion of the oldest individuals who regularly engage in physical activity remains very low [45, 46]. Additionally, there is a common belief that the oldest old individuals should not exercise, often because of perceived barriers.

Studies have shown that obstacles to physical exercise for the oldest old include the need for transportation assistance, as they often rely on family members or caregivers to leave the home, and feelings of insecurity due to poor road conditions, which heighten their fear of falling [47]. Nonetheless, our findings emphasize that both physical and mind exercises are crucial for the oldest old individuals and have a significant impact on ADL disability. Therefore, the oldest old should be encouraged to engage in moderate physical and mind exercises in a safe environment.

Our study has several limitations. First, the CLHLS only asks older adults whether they currently engage in physical or mind exercises, without further details on frequency, duration, or other specific metrics that are crucial and could impact the reliability of our results. Therefore, in future research, it will be important to thoroughly measure the specific details of physical or mental exercise among older adults and analyze the relationships between physical or mind exercise and ADLs at different frequencies and intensities by collecting longitudinal cohort data. Second, while we incorporated as many ADL-related disability factors as possible into the analysis as control variables, it is important to acknowledge that the current controls remain insufficient owing to limitations in the variables available in the CLHLS database. For example, critical factors such as muscle weakness, slowness in movement, physical activity levels, and weight loss were not effectively accounted for in the models. Future studies should therefore prioritize controlling for these additional covariates to further validate the robustness and reliability of the research findings. Third, owing to database limitations, we could not further examine the mechanisms by which physical and mind exercises might affect ADL disability in the oldest-old individuals. However, we speculate that this may be related to improvements in muscle strength among older adults. Therefore, future studies could apply more rigorous randomized controlled trials to further validate our findings and support the reliability of our conclusions.

Conclusion

Our analysis suggests that participation in both physical and mind exercises may contribute to reducing ADL disability risks among the oldest-old population. Specifically, older adults engaging solely in physical exercise appear to exhibit a lower likelihood of ADL disability compared to those who remain sedentary, though this association requires further validation. Conversely, individuals participating exclusively in mind stimulation activities show no discernible difference in ADL disability risk relative to non-participants. Of particular interest, the combined practice of physical and mind training may yield the most substantial protective effects, highlighting potential synergistic benefits for functional preservation in advanced age. Therefore, beyond encouraging the oldest-old to engage in appropriate physical exercise, it is also essential to promote simultaneous engagement in mind exercise. This dual approach is more beneficial for maintaining the health of the oldest-old and contributes to the promotion of healthy aging.

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Author contributions
Zhen Guo and Fei Wang contributed to data collection; Song Wang and Zhengyu Wu were major contributors to data collection and the writing of the manuscript; Zhengyu Wu, Song Wang, and Bo Liu participated in data interpretation and contributed to the writing of the manuscript. All authors have read and approved the final manuscript.

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Data availability
The datasets used and analyzed during the current study are available from the Peking University Open Research Data Platform (https://opendata.pku.edu.cn/dataverse/CHADS).

Declarations

Ethics approval and consent to participate
Written informed consent was obtained from all participants and/or their proxy respondents, and the study was approved by the Research Ethics Committee of Peking University (IRB00001052–13074) in accordance with the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. National Cancer Institute at the National Institutes of Health. In: NCI Dictionary of Cancer Terms-Definition of ADL. https://www.cancer.gov/publications/dictionaries/cancer-terms/def/adl. Accessed 16 October 2024.
2. Berlau DJ, Corrada MM, Peltz CB, Kawas CH. Disability in the Oldest-Old: incidence and risk factors in the 90 + Study. Am J Geriatr Psychiatry. 2012;20(2):159–68.
3. Zeng Y, Feng QS, Hesketh T, Christensen K, Vaupel JW. Survival, disabilities in activities of daily living, and physical and cognitive functioning among the oldest-old in China: a cohort study. Lancet. 2017;389(10079):1619–29.
4. Gill TM, Gahbauer EA, Han L, Allore HG. The role of intervening hospital admissions on trajectories of disability in the last year of life: prospective cohort study of older people. Bmj-Brit Med J. 2015;350.
5. Chatterji S, Byles J, Cutler D. Health, functioning, and disability in older adults-present status and future implications. Lancet. 2015;385(9967):563–75.
6. United Nations, Department of Economic and Social Affairs, Population Division. World population aging 2019 (ST/ESA/SER.A/444). New York: United Nations; 2020.

7. Resnick B, Ory MG, Hora K, Rogers ME, Page P, Chodzko-Zajko W, et al. The exercise assessment and screening for you (EASY) tool: application in the oldest old population. Am J Lifestyle Med. 2008;2(5):432–40.
8. Valenzuela PL, Castillo-Garcia A, Morales JS, Izquierdo M, Serra-Rexach JA, Santos-Lozano A et al. Physical exercise in the oldest old. Age. 2019;5(11.16).
9. Valenzuela PL, García AC, Morales JS, Santos-Lozano A, Lucia A. Athletic oldest-old: alive and kicking. J Am Med Dir Assoc. 2019;20(8):949–51.
10. Martínez-Velilla N, Valenzuela PL, Sáez de Asteasu ML, Zambom-Ferraresi F, Ramírez-Vélez R, García-Hermoso A, et al. Effects of a tailored exercise intervention in acutely hospitalized oldest old diabetic adults: an ancillary analysis. J Clin Endocrinol Metab. 2021;106(2):e899–906.
11. Lau LK, Tou NX, Jabbar KA, Tang JY, Gao J, Ding YY, et al. Effects of exercise interventions on physical performance and activities of daily living in oldest-old and frail older adults: A review of the literature. Am J Phys Med Rehabil. 2023;102(10):939–49.
12. Ho BD, Gullett JM, Anton S, Franchetti MK, Bharadwaj PK, Raichlen DA, et al. Associations between physical exercise type, fluid intelligence, executive function, and processing speed in the oldest-old (85+). GeroScience. 2024;46(1):491–503.
13. Kawas CH. The oldest old and the 90 + Study. Alzheimers Dement. 2008;4(1):S56–9.
14. Serra-Rexach JA, Bustamante-Ara N, Hierro Villaran M, Gonzalez Gil P, Sanz Ibanez MJ, Blanco Sanz N, et al. Short-term, light-to moderate-intensity exercise training improves leg muscle strength in the oldest old: a randomized controlled trial. J Am Geriatr Soc. 2011;59(4):594–602.
15. Cho C, Han C, Sung M, Lee C, Kim M, Ogawa Y, et al. Six-month lower limb aerobic exercise improves physical function in young-old, old-old, and oldest-old adults. Tohoku J Exp Med. 2017;242(4):251–7.
16. Layec G, Trinity JD, Hart CR, Le Fur Y, Zhao J, Reese V, et al. Impaired muscle efficiency but preserved peripheral hemodynamics and mitochondrial function with advancing age: evidence from exercise in the young, old, and oldest-old. J Gerontol Biol Sci Med Sci. 2018;73(10):1303–12.
17. Venturelli M, Reggiani C, Richardson RS, Schena F. Skeletal muscle function in the oldest-old: the role of intrinsic and extrinsic factors. Exerc Sport Sci Rev. 2018;46(3):188–94.
18. Punch S, Russell Z, Cairns. B.Forming identity in the mind-sport Bridge: self, partnership and community. Int Rev Sociol Sport. 2021;56(6):804–22.
19. Cheng ST, Chan AC, Yu EC. An exploratory study of the effect of Mahjong on the cognitive functioning of persons with dementia. Int J Geriatric Psychiatry: J Psychiatry Late Life Allied Sci. 2006;21(7):611–7.
20. Law LL, Barnett F, Yau MK, Gray MA. Effects of combined cognitive and exercise interventions on cognition in older adults with and without cognitive impairment: a systematic review. Aging Res Reviews. 2014;15:61–75.
21. Krell-Roesch J, Vemuri P, Pink A, Roberts RO, Stokin GB, Mielke MM, Geda YE. Association between mentally stimulating activities in late life and the outcome of incident mild cognitive impairment, with an analysis of the APOE E4 genotype. JAMA Neurol. 2017;74(3):332–8.
22. Verghese J, Lipton RB, Katz MJ, Hall CB, Derby CA, Kuslansky G, Buschke H. Leisure activities and the risk of dementia in the elderly. N Engl J Med. 2003;348(25):2508–16.
23. Fratiglioni L, Paillard-Borg S, Winblad B. An active and socially integrated lifestyle in late life might protect against dementia. Lancet Neurol. 2004;3(6):343–53.
24. Chu-Man L, Chang MY, Chu MC. Effects of Mahjong on the cognitive function of middle-aged and older people. Int J Geriatr Psychiatry. 2015;30(9):995–7.
25. Gao M, Sa Z, Li Y, Zhang W, Tian D, Zhang S, Gu L. Does social participation reduce the risk of functional disability among older adults in China? A survival analysis using the 2005–2011 waves of the CLHLS data. BMC Geriatr. 2018;18:1–13.
26. Proper KI, Singh AS, Van Mechelen W, Chinapaw MJ. Sedentary behaviors and health outcomes among adults: a systematic review of prospective studies. Am J Prev Med. 2011;40(2):174–82.
27. Thorp AA, Owen N, Neuhaus M, Dunstan DW. Sedentary behaviors and subsequent health outcomes in adults: a systematic review of longitudinal studies, 1996–2011. Am J Prev Med. 2011;41(2):207–15.
28. Kurita S, Doi T, Tsutsumimoto K, Hotta R, Nakakubo S, Kim M, Shimada H. Cognitive activity in a sitting position is protectively associated with cognitive impairment among older adults. Geriatr Gerontol Int. 2019;19(2):98–102.
29. Zou L, Loprinzi PD, Yeung AS, Zeng N, Huang T. The beneficial effects of mind-body exercises for people with mild cognitive impairment: a systematic review with meta-analysis. Arch Phys Med Rehabil. 2019;100(8):1556–73.
30. Gu D, Feng Q, Chen H, Zeng Y. Chinese longitudinal healthy longevity survey (CLHLS). Encyclopedia of gerontology and population aging. Springer; 2022. pp. 957–70.
31. Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. Studies of illness in the aged: the index of ADL: a standardized measure of biological and psychosocial function. JAMA. 1963;185(12):914–9.
32. Folstein MF, Folstein SE, McHugh PR. Mini-mental State: a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12(3):189–98.
33. Radloff LS. The CED-D scale: A self-report depression scale for research in the general population. Appl Psychol Meas. 1977;1:385–401.
34. Zhang L. Leisure activities and the oldest Old's health. Living longer and health.er at older ages: A longitudinal analysis of Chinese oldest Old's health. and its determinants. Springer; 2024. pp. 151–65.
35. Capanema BSV, Franco PS, Gil PR, Mazo GZ. A collective review of the research on training the oldest-old. Strength Cond J. 2022;44(6):94–115.
36. Maria Martone A, Lattanzio F, Marie Abbatecola A, La Carpia D, Tosato M, Marzetti E, et al. Treating sarcopenia in older and oldest old. Curr Pharm Des. 2015;21(13):1715–22.
37. Zhong WF, Wang XM, Liang F, Song WQ, Chen ZT, Li ZH, et al. Leisure-time activities and disability among Chinese community-dwelling oldest old: evidence from the Chinese longitudinal healthy longevity study. Eur J Public Health. 2024;34(6):1177–83.
38. Feng Q, Purser JL, Zhen Z, Duncan PW. Less exercise and more TV: leisure-time physical activity trends of Shanghai elders, 1998–2008. J Public Health (Oxf). 2011;33(4):543–50.
39. Feng Q, Fong JH, Zhang W, Liu C, Chen H. Leisure activity engagement among the oldest old in China, 1998–2018. Am J Public Health. 2020;110(10):1535–7.
40. Dunlop DD, Song J, Arntson EK, Semanik PA, Lee J, Chang RW, et al. Sedentary time in US older adults associated with disability in activities of daily living independent of physical activity. J Phys Act Health. 2015;12(1):93–101.
41. Jia J, Zhao T, Liu Z, Liang Y, Li F, Li Y et al. Association between healthy lifestyle and memory decline in older adults: 10 year, population based, prospective cohort study. BMJ. 2023;380.
42. Estrada-Plana V, Montanera R, Ibarz-Estruga A, March-Llanes J, Vita-Barrull N, Guzmán N, et al. Cognitive training with modern board and card games in healthy older adults: two randomized controlled trials. Int J Geriatr Psychiatry. 2021;36(6):839–50.
43. Decety J, Jackson PL, Sommerville JA, Chaminade T, Meltzoff AN. The neural bases of Cooperation and competition: an fMRI investigation. NeuroImage. 2004;23(2):744–51.
44. Heath JM, Stuart MR. Prescribing exercise for frail elders. J Am Board Fam Pract. 2002;15(3):218–28.
45. Izquierdo M, Castillo-Gallego C. Exercise for frail older people. J Nutr Health Aging. 2023;27(8):681–2.
46. Haider S, Grabovac I, Dorner TE. Effects of physical activity interventions in frail and prefrail community-dwelling people on frailty status, muscle strength, physical performance and muscle mass-a narrative review. Wien Klin Wochenschr. 2019;131(11–12):244–54.
47. Da Silva Capanema B, Fank F, Trento M, Costa DL, da Rocha A, Mazo GZ. Home-Based exercise programs for the Oldest-Old to attenuate physical frailty: A scoping review. J Frailty Aging. 2024:1–15.

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