Journal of Physical Activity and Health, 2020, 17, 736-743
https://doi.org/10.1123/jpah.2019-0336

Human Kinetics
ORIGINAL RESEARCH

Multiyear Square Dancing Is Associated With Superior Mental Processing Capacity But Not Memory in Middle-Aged and Older Chinese Women: A Cross-Sectional Propensity Score Matching Analysis

Jing Liao, Yung-Jen Yang, and Dong (Roman) Xu

Background: Evidence suggests the importance of physical activity and social engagement in cognitive preservation. Group-based dancing combining exercise and prosocial features may generate physical and cognitive benefits. **Objectives**: To investigate the association between multiyear habitual square dancing and domain-specific cognitive function, and assess the relative importance and joint impact of physical activity and social activity on cognition. **Methods**: Using the cross-sectional propensity score matching method, the study compared the mental status, episodic memory, and overall cognitive performances of 145 amateur female square-dancing participants (aged ≥45 y) to their sociodemographic- and health-status–matched 222 nondancing counterparts, selected from the China Health and Retirement Longitudinal Study. **Results**: The authors found a positive association between multiyear square dancing (average 8 y) and overall cognitive performances (mean difference = 2.84; 95% confidence interval [CI], 1.65 to 4.02), which was apparent in processing capacity (2.29; 95% CI, 1.51 to 3.07) but not in memory (0.55; 95% CI, –0.13 to 1.23). The hypothesized synergic effect of physical activity and social activity on cognition was only observed in group-based exercises embodying these 2 components simultaneously. **Conclusions**: Long-term square dancing as one type of physically and socially engaging activities may preserve cognition. Future longitudinal and interventional studies are needed to further clarify the causal relationship.

Keywords: group exercise, social engagement, multitasking, cognitive function

The preservation of cognitive function is a key component of successful aging.[1] To reduce the risk of cognitive decline and dementia, the recent World Health Organization guideline highlights the importance of leading a physically active and socially engaging healthy lifestyle, while acknowledging that more research is needed for social activity.[2] The epidemiological findings on 1.2 million American adults further indicate that group-based exercises, combining physical and prosocial features, may generate health benefits not only for the body but also for the brain.[3]

Chinese square dancing is a group-based physical activity performed to a variety of music in public squares and other open spaces. It is highly popular among middle-aged and retired women, who gather together in the early morning and/or evening after dinner, organize themselves into rank and file led by the most proficient dancers, and exercise with moderate intensity for around one and a half hours almost daily.[4] As an aerobic exercise accompanied by dance rhythm, square dancing mobilizes participants' whole body, which has been associated with improved capability of balance[5] and cardiopulmonary function.[6] Through lively music and coordinated dance movements, square dancing also engages various cognitions, such as executive function, memory, and motor skills.[7] In addition, square dancing creates a socially enriched environment for participants to interact with peers.[5]

Liao is with the Department of Medical Statistics, School of Public Health, Sun Yat-sen University, Guangzhou, Guangdong, China. Liao and Xu are with the Sun Yat-sen Global Health Institute, School of Public Health, Institute of State Governance, Sun Yat-sen University, Guangzhou, Guangdong, China. Yang is with the Institute of Education, University College London, London, UK. Xu (roman.xu@gmail.com) is corresponding author.

Square dancing is physically and cognitively challenging, but its potential cognitive benefits have been underinvestigated. Although a positive association between square dancing and improved overall cognitive performance has been reported by some small-scale observational[8] and interventional studies,[9] these studies did not provide adequate information on confounder adjustment or clear selection for the comparison group. Examining a global cognitive score only, these studies also cannot identify cognitive domains that may be specifically stimulated by square dancing. Dancing, in general, requires cognitive functions, such as learning and memorizing motor sequences, attention, as well as synchronization in time and space.[10] Depending on the dancer's proficiency and dance styles (eg, complexity and rhythm movements), the cognitive domains involved in dancing may differ.[10] Kosmat and Vranić[11] revealed that older adults who underwent 10-week Waltz training had improved executive function and short-term memory scores compared to their controlled counterparts. On the other hand, Marquez et al[12] found greater improvement in episodic memory but not in executive function of the novice Latin dance group compared with the health education group. The extent to which square dancing would be associated with domain-specific cognitive function is unknown.

Furthermore, the unique contribution of the physical and social components of square dancing to cognitive function has been rarely explored. Physical activity and social activity independently have been shown to be cognitively beneficial,[13,14] but their relative importance to and joint impact on cognitive function are less studied. Given that social interactions with other square-dancing participants may recruit a wider-spread neural network than exercise alone,[15] a synergic effect of physical activity and social activity on cognition would be expected. However, Merom et al[16] failed to support this potential superior cognitive stimulation function of dancing overwalk among older adults aged 60 years and older, showing a small cognitive improvement of similar magnitude in both groups after an 8-month training program. Despite the advantages in establishing causal relationships, experimental studies employing dancing as an intervention for cognitive improvement are limited to small sample sizes, short exposures, and participants' poor compliance to prescribed interventions.

Therefore, the current study aimed to investigate the association between multiyear (≥1 y) habitual square dancing and domain-specific cognitive function. It was hypothesized that multiyear dancing would be associated with improved cognitive performances, and this association would vary across cognitive domains. The interactive roles of physical activity and social activity for cognition were further examined, hypothesizing a synergic effect if both components presented.

Methods

Participants

The current study used 2 study samples: the square-dancing sample of participants dancing regularly for more than 1 year and the nondancing sample selected from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative sample of Chinese community older dwellers.[17] Square-dancing participants were recruited from major squares and parks of 3 old districts of Guangzhou, Guangdong, from November 2017 to May 2018. Altogether, 145 female community dwellers aged 45 years and older who practiced square dancing at least once per week in the past 12 months and completed the survey questionnaire, cognition assessments, and physical assessments formed the square-dancing sample. Their female comparisons were selected from the latest 2014–2015 CHARLS survey; they lived in the urban community and did not go to any sport, social, or other kinds of club, resulting in an initial analytic sample of 2103 (before propensity score matching).

Statement of Ethics

Our study complied with the guidelines for human studies and was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. The square-dancing study was approved by the institutional review board of Sun Yat-sen University, and CHARLS was approved by the ethical review committee of Peking University. The participants of both studies provided written consent.

Measures

Cognition Assessments. Consistent with CHARLS,[18–20] cognitive function was assessed with the same set of cognitive tests and was examined through face-to-face interviews in both study samples. CHARLS adapted these cognitive tests from the US Health and Retirement Study[21] and validated them against the Chinese context,[17,19] with the mental status component and episodic memory component derived from factor analysis.

The mental status component, primarily capturing mental processing capacity and alertness,[21] included cognitive tests on orientation and numeric ability. Orientation was assessed by 5 items[17] selected from the Telephone Interview for Cognitive Status,[22] namely today's date (day, month, and year), day of the week, and current season. Numeric ability was assessed by the serial subtraction of 7 from 100 (up to 5 times). Correct answers of these items were aggregated to form a single score, ranging from 0 to 10.[18]

The episodic memory component was assessed through immediate and delayed recall tests. The respondents were asked to memorize and immediately recall as many words in any order as they could after the interviewers read out a list of 10 Chinese nouns (immediate recall). After 4 to 10 minutes, they were asked to recall as many those words as possible in any order (delayed recall). An episodic memory score was the average number of the correct words in immediate and delayed recalls, and it ranged from 0 to 10.

A composite cognitive score (range 0–20) was calculated by summing up both the mental status component and episodic memory component to indicate the overall cognitive performance.

Physical Activity. Physical activity was measured by the Chinese version of the International Physical Activity Questionnaire,[23] to quantify physical activity by its intensity, frequency, and duration. The CHARLS participants were asked whether they did any vigorous or moderate physical activity in a usual week, and the number of days per week and duration per time doing these activities. To better quantify its physical activity features, the square-dancing participants were specifically asked about their dance frequency (ie, number of days per week practicing square dancing), dance duration each time in minutes, and self-rated intensity (ie, "Does square dancing cause increases in breathing or sweating, and is it light, moderate or hard?"). The number of years that the participants had been practicing square dancing at least once per week was also recorded. Physical activity other than square dancing was measured by its frequency, duration, and intensity. To maximize the comparability between samples and to reflect the World Health Organization's physical activity recommendations for older adults,[24] the participants of both samples were coded as physically active (PA) if they conducted moderate to vigorous physical activity at least 150 minutes per week, as recommended (PA = 1) or not (PA = 0).

Social Activity. Similar to CHARLS,[25] social activities for the square-dancing sample were measured by the type (ie, visiting friends, playing Mahjong or board games, etc, taking part in a community-related organization, volunteering, or attending educational courses) and frequency (ie, almost daily, at least once per week, or not regularly) of these activities that the participants engaged in during the last month. The participants were coded as socially active (SA) if they did any above social activities on a weekly basis (SA = 1) or not (SA = 0).

Based on different combinations of physical- and social-activity levels, the following 4 groups were formed: inactive (ie, neither PA nor SA), PA only, SA only, and PA and SA (most active subgroup).

Covariates. Sociodemographic characteristics, including age, marital status, education, and retirement status (ie, retired or not), as well as 2 indicators of physical health status, namely, doctor-diagnosed diseases and body mass index (BMI), were included as key indicators in the propensity score calculation. These covariates were selected based on the comparability of measurements available across the 2 studies and their associations with cognitive outcomes and the propensity of grouping, as suggested by the literature.[26,27] All covariates were collected by self-reported questionnaires, except for the BMI (in kg/m^2) determined as weight (in kg) divided by height (in m^2) measured by nurses at primary health care centers.

Statistical Analyses

Propensity score matching was applied to compare square-dancing and selected CHARLS female participants. The propensity score was calculated using a logistic regression model with age, marital status, education, retirement status, doctor-diagnosed diseases, and BMI as covariates. Matching on the propensity score was performed by *k*:1 nearest neighbor matching with a caliper distance of 0.25 SD of the propensity scores.[28] A comparison-to-treatment ratio of 3:1 was chosen to maintain most of the treatment group with adequate matches. The matching quality was evaluated by the standardized mean difference of the propensity score and covariates, the percentage bias reduction, and the variance ratio.[29] For an adequate match, the standardized mean difference should be close to 0,[30] the percentage bias reduction should be 80% and above, and the variance ratio should be close to 1.[29] Comparison in 3 cognitive function scores was conducted separately for the matched samples. A subgroup analysis of global cognitive scores with years of dancing, divided into 1–5, >5–10, and >10 years, was conducted to explore a dose–response association. Logistic regression with propensity score adjustment was applied to compare the differences in cognitive scores of the 4 PA and SA subgroups of CHARLS in reference to the most active group of square-dancing participants (ie, PA and SA). STATA (version 14.0; StataCorp, College Station, TX) was used for all analyses, with a 2-sided $P < .05$ as statistically significant.

Results

Table 1 shows the characteristics of the selected CHARLS and square-dancing participants before propensity score matching. Although both samples were composed of married women aged around 60 years, the square-dancing participants had higher education levels, were more likely to be retired, reported fewer diagnosed chronic diseases, and had smaller BMI than their CHARLS counterparts (all *P*s < .001). The square-dancing participants also scored higher in episodic memory, mental status, and composite cognitive scores than the CHALLS comparisons (all *P*s < .001). The square-dancing sample danced for an average of 8 years, with 44% for 1–5 years, 36% for >5–10 years, and 20% for >10 years (data not shown). This sample had nearly 5 times more participants who were both PA and SA than the selected CHARLS sample (66% vs 14%). The physical activity level for the square dancers was mainly dependent on their dancing-related PA. Although 58% of the square dancers (n = 84) also took part in PA other than dancing, most of them (68%) reported activities of light intensity (ie, walking). Out of the remaining 27 reporting moderate activities other than dancing, 26 were considered as PA in line with their dancing intensity and time per week, with only one participant exercising <30 minutes per week.

After propensity score matching, 222 CHARLS participants were matched with 138 square-dancing participants (95% of the original sample). As shown in Table 2, all baseline covariates were balanced between the 2 matched groups (all *P*s > .05), and the propensity scores for both samples had mean values of 0.3 (standardized mean difference = 0.0) with equal variances (variance ratio = 1.0), suggesting an adequate match.

Table 3 presents the differences in the cognitive function scores after propensity score matching. The composite cognitive score was 2.84 higher (95% confidence interval [CI], 1.65–4.02) in the square-dancing participants than their matched CHARLS counterparts. The difference in this overall measure was mainly driven by the difference in the mental status scores (2.29; 95% CI, 1.51 to 3.07), while the difference in the episodic memory scores of

Table 1 Characteristics of Selected CHARLS and Square-Dancing Participants Before Matching

Characteristics	CHARLS sample (n = 2103)		Square-dancing sample (n = 145)		P for group difference
Sociodemographic characteristics					
Age, mean (SD), y	60.2	9.8	60.6	5.7	.59
Education level, %					<.001
Primary school and below	65.1		5.5		
Junior high school	20.6		17.2		
Senior high school	13.7		58.0		
University and above	0.6		19.3		
Retired, %	51.9		91.7		<.001
Married, %	83.0		86.2		.31
Physical health status					
Diagnosed chronic disease, %	69.6		53.1		<.001
BMI, mean (SD)	24.7	3.9	23.1	2.6	<.001
Cognitive function					
Episodic memory score, range 0–10	3.6	1.9	4.8	1.7	<.001
Mental status score, range 0–10	5.8	3.4	8.7	1.7	<.001
Composite cognitive score, range 0–20	9.3	4.4	13.4	2.9	<.001
PA and SA groups[a]					<.001
Inactive	39.3		4.2		
PA only	30.9		24.1		
SA only	15.6		6.2		
PA and SA	14.2		65.5		

Abbreviations: BMI, body mass index; CHARLS, China Health and Retirement Longitudinal Study; PA, physically active; SA, socially active.
[a]PA participants were those who conducted moderate to vigorous physical activity at least 150 minutes per week. SA participants were those who did weekly social activity. Based on PA and SA combinations, 4 groups were formed: inactive (neither PA nor SA), PA only, SA only, and PA and SA.

Table 2 Characteristics of Selected CHARLS and Square-Dancing Participants After Propensity Score Matching

Characteristics	CHARLS sample (n = 222)		Square-dancing sample (n = 138)		%Bias reduction	*P* for difference	V(T)/V(C)
Age, mean (SD), y	60.3	8.7	60.6	5.7	35.5	.74	0.43
Education level, %					97.5	.69	
Primary school and below	6.3		5.6				
Junior high school	15.0		17.6				
Senior high school	65.8		59.2				
University and above	12.9		17.6				
Retired, %	94.8		91.5		91.8	.27	
Married, %	88.9		85.9		9.2	.46	
Diagnosed chronic disease, %	59.4		53.5		64.4	.32	
BMI, mean (SD)	23.0	3.1	23.1	2.6	88.0	.57	0.73
Propensity score, mean (SD)	0.3	0.2	0.3	0.2	/	.99	1.00

Abbreviations: BMI, body mass index; CHARLS, China Health and Retirement Longitudinal Study; V(T)/V(C), the variance ratio of treated (T) over nontreated (C) for continuous covariates. Note: %Bias reduction is the percentage of between-group differences being reduced after propensity score matching. *P* tests the equality of distributions of the 2 samples.

Table 3 Cognitive Score Differences Between Square-Dancing Participants (n = 138) and the Matched CHARLS Participants (n = 222) by Propensity Score

Cognitive score	ATE[a]	Robust SE	*P* value	95% CI	
Composite cognitive score, range 0–20	2.84	0.60	<.001	1.65	4.02
Episodic memory score, range 0–10	0.55	0.35	.11	−0.13	1.23
Mental status score, range 0–10	2.29	0.40	<.001	1.51	3.07

Abbreviations: ATE, average treatment effect; CHARLS, China Health and Retirement Longitudinal Study; CI, confidence interval.
[a]ATE indicates the adjusted mean cognitive difference between square-dancing group (treatment) and the matched CHARLS comparison (control). Indicators included in the propensity matching score were age, marital status, education, retirement status, doctor-diagnosed diseases, and body mass index.

these 2 matched samples was not statistically significant (0.55; 95% CI, −0.13 to 1.23). Although the subgroup analysis showed a positive trend between higher cognitive scores and longer years of dancing (*P* for trend < .001, with CHARLS as comparison), the largely overlapped 95% CIs of the estimated cognitive differences of the 3 dancing-year subgroups indicated that our study was probably underpowered to detect the between-dancing groups' differences (Appendix).

Figure 1 illustrates the cognitive score differences by subgroups of physically and socially in/active participants. Compared with the PA and SA square-dancing participants, the composite cognitive scores were lower in all subgroups of CHARLS participants, from 1.69 points (95% CI, 0.31 to 3.08) of the PA-only group to 3.01 points (95% CI, 1.79 to 4.22) of the inactive group. Similar patterns were found in the mental status scores, while the differences in the episodic memory scores were statistically insignificant.

Discussion

Our study investigated the associations between multiyear habitual square dancing with several cognitive performances, and the joint impact of physical activity and social activity on these associations. We found better cognitive performances of female square-dancing participants than their matched nondancing CHARLS counterparts, while a clear dose–response association between cognition and years of dancing was not identified. The cognitive score differences were apparent in the mental status component, which mainly measured mental processing capacity and orientation,[21] but not in the episodic memory component. The hypothesized synergic effect of physical activity and social activity on cognitive function was only present between the most active square-dancing participants against the 4 PA versus SA subgroups of CHARLS.

In line with previous studies identifying positive impacts of dancing on cognition,[5,9] our study found that the square-dancing participants had better cognitive performances than their nondancing comparisons. We previously reported that participants dancing for longer years tended to have higher PA levels and were less likely to be sedentary than their counterparts who danced irregularly or <1 year.[4] The current analysis only included these regular dancers, around half of whom practiced square dancing between 1 and 5 years, while only one-fifth danced over 10 years. The limited number of participants with longer years of dancing may lead to insufficient power to detect any potential dose–response association in the subgroup analysis of dancing years. We further examined the cognitive domain-specific associations, using several cognitive tests instead of one single global score, as in previous studies.[5,8] Our study showed differences in cognitive tests involving processing capacity and orientation but not episodic memory. This selective preservation of cognitive function may be due to the physical feature of square dancing. As a form of aerobic exercise, square dancing has been found to be most beneficial for executive processing.[31] More importantly, square dancing as a multitask exercise[11] requires simultaneous

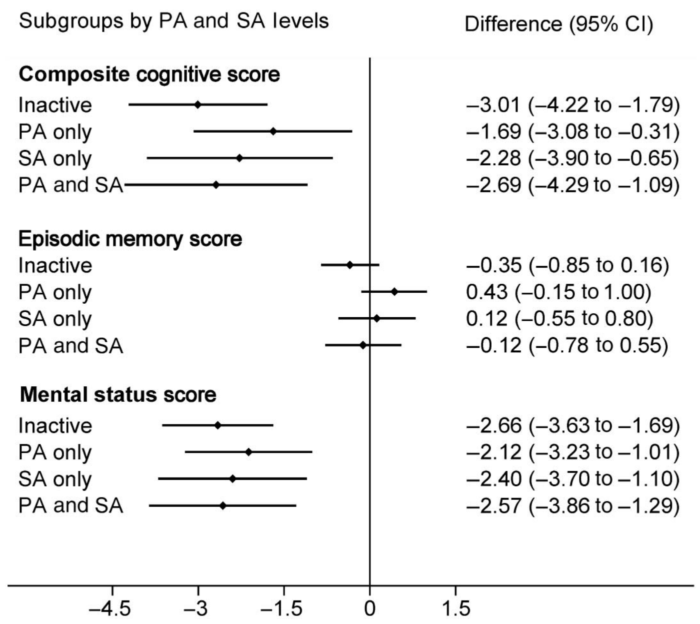

Figure 1 — Cognitive score differences between CHARLS neither PA nor SA group (inactive, n = 95), PA-only group (n = 56), SA-only group (n = 35), or both PA and SA (n = 36), in reference to square-dancing PA and SA group (n = 93). All models adjusted for propensity score as covariate. CHARLS indicates China Health and Retirement Longitudinal Study; CI, confidence interval; PA, physically active; SA, socially active.

listening and processing of music, dancing to the rhythm with coordinated body movements, as well as attention between movement and balance. These tasks need great attention, orientation, and concentration,[32] which are constantly mediated by a central executor and do not become voluntary over time.[31] On the other hand, as our square-dancing participants had been practicing dancing for many years, they may already be familiar with highly repetitive dance movements and simply follow the leading dancers' instructions, such that the memorizing effort required may not be as high as it would be for novice dancers.[11,12]

The hypothesized synergic effect between physical activity and social activity on the square dancing–cognitive function association was partially supported by the current study. The observed superior cognitive performances of square-dancing participants over their CHARLS counterparts doing either physical activity or social activity corresponded to the enriched environment theory,[5] highlighting the importance of dancing activities' diversity, which integrated physical and social components.[14] However, our findings noted that the interaction between physical activity and social activity may not be clear-cut, as the CHARLS participants who were both PA and SA had no better cognitive performances than their PA- or SA-only counterparts. We purposely selected CHARLS participants who were not members of any sport or social group, to make a fair comparison with the square-dancing sample. It is suspected that these PA and SA CHARLS participants were doing physical activity without any companion, and the social activities reported were mostly sedentary (eg, playing Mahjong, attending educational courses), which may offset the health benefits of exercising.[33]

Our study contributes to the literature by demonstrating the cognitive domain-specific associations with multiyear square dancing among a group of older amateur dancers and their matched nondancing comparisons, selected from the nationally representative CHARLS cohort, allowing for a large sample size to detect the treatment effect and improve generalizability. However, several limitations should be acknowledged. First, being limited by the observational study design, our findings might nonetheless reflect reverse causation, as individuals with better cognition would tend to participate in square dancing. Second, the square-dancing and CHARLS participants were interviewed 3 years apart, resulting in an average of 3-year difference in birth years for these of the same age. To examine the potential cognitive differences due to the birth cohort, which cannot be built into the propensity score due to collinearity with age, we additionally adjusted for the birth year along with the propensity scores in the regression models. The almost unchanged results indicated that the observed higher cognitive scores of the square-dancing participants compared to their CHARLS comparisons were unlikely to be a product of different birth cohorts, namely the Flynn effect.[34]

Third, we adopted the propensity score matching method to reduce bias due to confounding factors, matching on available covariates associated with cognitive function and the treatment assignment. Although adequate covariate balance was shown in the matched samples, we acknowledge that our study may not entirely be immune from residual confounders. Fourth, the scope of our cognitive tests was limited by the time slot allowed in the interview. We followed the recommended practice in cognitive epidemiology, using a cognitive battery of several tests to assess the main components of cognitive function in accordance with previous studies.[18–20] Furthermore, studies with domain-specific cognitive measurements are needed to strengthen the clinical relevance of our findings. Finally, with the self-reported measures of physical activity and social activity, our study may be subject to recall bias and reporting bias, and the extent to which these 2 activities would overlap with each other cannot be strictly evaluated. Future studies facilitated by objective measures, such as those with mobile technology (eg, wearable activity trackers), may generate objective and even real-time data on participants' physical activity levels. Longitudinal follow-ups can provide additional information to explore the association between square-dancing and a cognitive aging trajectory over time.

To conclude, the present study shows a positive association between multiyear habitual square-dancing and overall cognitive performances, specifically with mental processing capacity and orientation. The synergic effect of physical activity and social activity on cognition tends to occur in group-based activities integrating these 2 components jointly, rather than being conducted separately. Physical activity promotion among older adults thus may gain from incorporating social interaction components and leveraging existing community resources.[4] Featured by its low cost and easy participation, square dancing holds considerable promise as a culturally appropriate group intervention for health promotion, which may facilitate the cognitive preservation of older adults.

Acknowledgments

The authors would like to thank Qianxin Chen, Xueqi Li, and Wenjun He of the School of Public Health, Sun Yat-sen University, for their assistance in data cleaning and literature research, as well as Dr Shuhua Sun and Dr Shixing Liu of the Division of Health Management, Shayuan Primary Health Care Center, for their support in recruiting the study participants. The authors have no conflicts of interest to declare. This study was supported by the Natural Science Foundation of Guangdong Province (2017A030310346 and 2018A0303130046) and Sun Yat-sen Scientific Research Foundation for Early Career Researchers (17ykpy15). The

sponsors had no roles in the study design, data collection or analysis, or the preparation of the manuscript.

References

1. Depp CA, Jeste DV. Definitions and predictors of successful aging: a comprehensive review of larger quantitative studies. *Am J Geriatr Psychiatry*. 2006;14(1):6–20. PubMed ID: 16407577 doi:10.1097/01.JGP.0000192501.03069.bc
2. World Health Organization. *Risk Reduction of Cognitive Decline and Dementia: WHO Guidelines*. Geneva, Switzerland: World Health Organization; 2019.
3. Chekroud SR, Gueorguieva R, Zheutlin AB, et al. Association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: a cross-sectional study. *Lancet Psychiatry*. 2018;5(9):739–746. PubMed ID: 30099000 doi:10.1016/S2215-0366(18)30227-X
4. Liao J, Chen S, Chen S, Yang YJ. Personal and social environmental correlates of square dancing habits in Chinese middle-aged and older adults living in communities. *J Aging Phys Act*. 2019;27(5):696–702. doi:10.1123/japa.2018-0310
5. Kattenstroth J-C, Kolankowska I, Kalisch T, Dinse HR. Superior sensory, motor, and cognitive performance in elderly individuals with multi-year dancing activities. *Front Aging Neurosci*. 2010;2:31. PubMed ID: 20725636
6. Liu SJ, Guo XD. Comparative research of middle-aged women fitness effects of Taiji Quan and square dance. *China Sport Sci Technol*. 2013;49(5):103–105.
7. Foster PP. How does dancing promote brain reconditioning in the elderly? *Front Aging Neurosci*. 2013;5:4. PubMed ID: 23447744 doi:10.3389/fnagi.2013.00004
8. Chen P, Bao Z, Guo X, Weng J, Xu H, Zhou D. Square dance and mental health and cognitive function of middle- and older-aged adults in Guangzhou. *J Electrocardiogram*. 2017;6(2):162–165.
9. Zhang X, Ni X, Chen P. Study about the effects of different fitness sports on cognitive function and emotion of the aged. *Cell Biochem Biophys*. 2014;70(3):1591–1596. PubMed ID: 24997050 doi:10.1007/s12013-014-0100-8
10. Brown S, Martinez MJ, Parsons LM. The neural basis of human dance. *Cereb Cortex*. 2006;16(8):1157–1167. PubMed ID: 16221923 doi:10.1093/cercor/bhj057
11. Kosmat H, Vranić A. The efficacy of dance intervention as a cognitive training for old-old. *J Aging Phys Act*. 2016;25(1):1–32.
12. Marquez DX, Wilson R, Aguiñaga S, et al. Regular Latin dancing and health education may improve cognition of late middle-aged and older Latinos. *J Aging Phys Act*. 2017;25(3):482–489. PubMed ID: 28095105 doi:10.1123/japa.2016-0049
13. Northey JM, Cherbuin N, Pumpa KL, Smee DJ, Rattray B. Exercise interventions for cognitive function in adults older than 50: a systematic review with meta-analysis. *Br J Sports Med*. 2018;52(3):154–160. PubMed ID: 28438770 doi:10.1136/bjsports-2016-096587
14. 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):343–353. PubMed ID: 15157849 doi:10.1016/S1474-4422(04)00767-7
15. Saarela MV, Hari R. Listening to humans walking together activates the social brain circuitry. *Soc Neurosci*. 2008;3(3–4):401–409. PubMed ID: 18633834 doi:10.1080/17470910801897633
16. Merom D, Grunseit A, Eramudugolla R, Jefferis B, Mcneill J, Anstey KJ. Cognitive benefits of social dancing and walking in old age: the dancing mind randomized controlled trial. *Front Aging Neurosci*. 2016;8:26. PubMed ID: 26941640 doi:10.3389/fnagi.2016.00026
17. Zhao Y, Hu Y, Smith JP, Strauss J, Yang G. Cohort profile: the China Health and Retirement Longitudinal Study (CHARLS). *Int J Epidemiol*. 2014;43(1):61–68. PubMed ID: 23243115 doi:10.1093/ije/dys203
18. Li J, Cacchione PZ, Hodgson N, et al. Afternoon napping and cognition in Chinese older adults: findings from the China Health and Retirement Longitudinal Study baseline assessment. *J Am Geriatr Soc*. 2017;65(2):373–380. PubMed ID: 27995615 doi:10.1111/jgs.14368
19. Lei X, Smith JP, Sun X, Zhao Y. Gender differences in cognition in China and reasons for change over time: evidence from CHARLS. *J Econ Ageing*. 2014;4:46–55. doi:10.1016/j.jeoa.2013.11.001
20. Luo Y, Pan X, Zhang Z. Productive activities and cognitive decline among older adults in China: evidence from the China Health and Retirement Longitudinal Study. *Soc Sci Med*. 2019;229:96–105. PubMed ID: 30274688 doi:10.1016/j.socscimed.2018.09.052
21. Mcardle JJ, Fisher GG, Kadlec KM. Latent variable analyses of age trends of cognition in the health and retirement study, 1992–2004. *Psychol Aging*. 2007;22(3):525–545. PubMed ID: 17874952 doi:10.1037/0882-7974.22.3.525
22. Brandt J, Spencer M, Folstein M. The telephone interview for cognitive status. *Neuropsychiatry Neuropsychol Behav Neurology*. 1988;1(2):111–117.
23. Deng HB, Macfarlane DJ, Thomas GN, et al. Reliability and validity of the IPAQ-Chinese: the Guangzhou Biobank Cohort study. *Med Sci Sports Exerc*. 2008;40(2):303–307. doi:10.1249/mss.0b013e31815b0db5
24. World Health Organization. *Global recommendations on physical activity for health*. 2010; 1–58. https://www.who.int/dietphysicalactivity/factsheet_recommendations/en/. Accessed May, 2019.
25. Lin W. A study on the factors influencing the community participation of older adults in China: based on the CHARLS 2011 data set. *Health Soc Care Community*. 2017;25(3):1160–1168. PubMed ID: 28178751 doi:10.1111/hsc.12415
26. Plassman BL, Williams JW, Burke JR, Tracey H, Sophiya B. Systematic review: factors associated with risk for and possible prevention of cognitive decline in later life. *Ann Intern Med*. 2010;153(3):182–193. PubMed ID: 20547887 doi:10.7326/0003-4819-153-3-201008030-00258
27. Berkman LF, Glass T, Brissette I, Seeman TE. From social integration to health: Durkheim in the new millennium. *Soc Sci Med*. 2000;51(6):843–857. PubMed ID: 10972429 doi:10.1016/S0277-9536(00)00065-4
28. Rosenbaum PR, Rubin DB. Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *Am Stat*. 1985;39(1):33–38.
29. Rubin DB. Using propensity scores to help design observational studies: application to the tobacco litigation. *Health Serv Outcomes Res Methodol*. 2001;2(3–4):169–188. doi:10.1023/A:1020363010465
30. Austin PC. Optimal caliper widths for propensity-score matching when estimating differences in means and differences in proportions in observational studies. *Pharm Stat*. 2011;10(2):150–161. PubMed ID: 20925139 doi:10.1002/pst.433
31. Colcombe S, Kramer AF. Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychol Sci*. 2003;14(2):125–130. PubMed ID: 12661673 doi:10.1111/1467-9280.t01-1-01430

32. Mochizuki AA, Kirino E. Effects of coordination exercises on brain activation: a functional MRI study. *Int J Sport Health Sci*. 2008;6: 98–104. doi:10.5432/ijshs.6.98
33. Patel AV, Bernstein L, Deka A, et al. Leisure time spent sitting in relation to total mortality in a prospective cohort of US adults. *Am J Epidemiol*. 2010;172(4):419–429. PubMed ID: 20650954 doi:10.1093/aje/kwq155
34. Flynn JR. The mean IQ of Americans: massive gains 1932 to 1978. *Psychol Bull*. 1984;95(1):29–51. doi:10.1037/0033-2909.95.1.29

Appendix: Total Cognitive Score Differences Between 3 Square-Dancing Groups by Years of Dancing and the Matched CHARLS Participants (n = 222) by Propensity Score

Years of dancing	No.	ATE[a]	Robust SE	*P* value	95% CI	
0 (CHARLS)	222	Ref			*P* for trend <.001	
1–5	62	2.15	0.67	<.001	0.83	3.46
>5–10	49	3.76	0.85	<.001	2.09	5.43
>10	27	3.56	1.56	<.001	0.50	6.61

Abbreviations: ATE, average treatment effect; CHARLS, China Health and Retirement Longitudinal Study; CI, confidence interval.
[a]ATE indicates the adjusted mean cognitive difference between corresponding years of dancing groups (treatment) and the matched nondancing CHARLS comparison (control, 0 y of dancing). Indicators included in the propensity matching score were age, marital status, education, retirement status, doctor-diagnosed diseases, and body mass index.