Clinical Interventions in Aging

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Effects of momentum-based dumbbell training on cognitive function in older adults with mild cognitive impairment: a pilot randomized controlled trial

This article was published in the following Dove Press journal:
Clinical Interventions in Aging
22 December 2015
Number of times this article has been viewed

Jiaojiao Lü[1]
Mingyun Sun[2,3]
Leichao Liang[1]
Yi Feng[1]
Xiaoyu Pan[1]
Yu Liu[1]

[1]Key Laboratory of Exercise and Health Sciences of Ministry of Education, Shanghai University of Sport, Shanghai, [2]Institue of Physical Education, Anqing Normal University, Anqing, [3]Institute of Intelligent Machines, Chinese Academy of Sciences, Hefei, People's Republic of China

Purpose: The purpose of this study was to explore the effects of an innovative momentum-based dumbbell-training intervention on cognitive function in older adults with mild cognitive impairment (MCI).

Subjects and methods: A total of 45 community-dwelling older adults with MCI were randomly assigned to either a dumbbell-training group (DTG; n=22) or a control group (CG; n=23). Participants in the DTG participated in exercise sessions three times weekly for 12 weeks. The primary outcome measures were cognitive function, including the Alzheimer's Disease Assessment Scale (ADAS) – Cognitive subscale, Trail Making Test part B, Digit Span Test (DST) – forward, and DST – backward, with secondary outcome measures being Timed Up and Go, functional reach, and the Activities-Specific Balance Confidence Scale.

Results: In an intent-to-treat analysis, participants in the DTG had significantly improved ADAS – Cognitive subscale scores compared to those in the CG (5.02 points, $P=0.012$). There was a significant within-group change (improvement) in Trail Making Test part B (33.32 seconds, $P<0.001$) and DST – backward (0.41 points, $P=0.025$) scores. No change was observed for the DST – forward measure. Participants in the DTG also improved their functional mobility compared to those in the CG (Timed Up and Go, 0.81 seconds; $P=0.043$).

Conclusion: There is preliminary evidence showing the potential benefit of momentum-based dumbbell training for improving cognitive function in older adults with MCI.

Keywords: exercise intervention, cognition, physical performance, older adults, mild cognitive impairment

Introduction

With the escalation of the aging population worldwide, dementia has become a major public health concern. In 2010, the number of older adults worldwide living with dementia was estimated to be 35.6 million; the number is expected to double by 2030 and more than triple by 2050.[1] In the People's Republic of China (PRC), 6–7 million people live with dementia, with an incidence rate between 5% and 7% for people 65 years of age and older.[2]

Alzheimer's disease (AD) is the most common form of dementia, accounting for 60%–70% of cases. If the disease onset could be delayed by 12 months, there would be 9.2 million fewer cases of AD.[3] Therefore, early diagnosis and treatment are becoming critically important in order to reduce the prevalence of dementia in the elderly. Mild cognitive impairment (MCI) is a transitional state between healthy

Correspondence: Yu Liu
Key Laboratory of Exercise and Health Sciences of Ministry of Education, Shanghai University of Sport, 399 Changhai Road, Yangpu, Shanghai 200438, People's Republic of China
Email yuliu@sus.edu.cn

aging and dementia.[4] Elderly individuals with MCI are at higher risk for developing AD, with estimates ranging from 10% to 15% annually, while this rate among normal elderly individuals is only 1%–2%.[4]

Given that no effective pharmacological treatment exists for individuals with MCI to alter or slow the progression of cognitive decline,[5–7] there has been growing interest in adopting lifestyle-change approaches, such as exercise, to prevent and/or reduce risk of developing dementia. Observational studies have shown that people who have MCI but are physically active tend to have slower cognitive decline and slower progression to dementia in later life.[8–12] Randomized controlled studies have demonstrated that exercise or physical activity (eg, aerobic exercise, resistance training, multimodal exercises) may well provide cognitive benefits, including improved global cognitive function, executive function, memory, attention,[13–15] and brain health[16,17] to older adults with cognitive disorders. Therefore, exercise has many health benefits that positively impact cognitive function and reduce vascular risks for developing dementia.[18]

In this proof-of-concept study, we explored whether a momentum-based dumbbell-training intervention would improve cognitive function in older adults with MCI. Momentum-based dumbbell training is a self-initiated spinning exercise that uses dumbbells to generate momentum while performing exercise movements with varying configurations aimed at concurrently challenging physical and cognitive abilities. Our approach was based on preliminary findings showing that the use of momentum-based bodybuilding equipment (eg, dumbbells and barbells) was safe and feasible, and improved mobility, balance, strength, posture stability, and quality of life.[19,20] Building on this preliminary work,[20] the main purpose of our study was to explore the effects of momentum-based dumbbell training on cognitive function in older adults with MCI. A secondary purpose was to examine its effects on physical performance. It was hypothesized that spinning dumbbell training would lead to improvement in cognitive function and physical performance among older adults with MCI.

Subjects and methods

Study design

We conducted a pilot randomized controlled trial with two experimental groups: a dumbbell-training group (DTG) and a control group (CG), with participants in the DTG taking part in an exercise session three times per week for 12 weeks. The study protocol was approved by the ethics committee of the Shanghai University of Sport, and written informed consent was obtained from all study participants.

Participants

Participants were recruited from three communities in Shanghai, PRC. Study eligibility criteria were: 1) ≥65 years of age; 2) memory complaint with typical general cognitive function (Mini-Mental Status Evaluation [MMSE][21] ≥24,[22] Montreal Cognitive Assessment [MoCA][23] <26;[24] 3) the ability to perform daily living activities (Activities of Daily Living scale <26);[25] and 4) not clinically demented.[4] Individuals were excluded if they: 1) had any musculoskeletal or joint problems, major neurological, cardiac, or cerebrovascular diseases, or other medical diseases associated with cognition and physical performance; 2) were unable to make a 12-week commitment during the study period; or 3) were participating in any regular physical activities or exercise programs.

Recruitment, randomization, masking, and baseline measurement

Participants were recruited primarily through initial contacts with community leaders and presentations at community centers, where study protocols (assessment, group assignment, and training) were described in detail. Those who qualified for study eligibility were assigned randomly to either the DTG or CG. Group-allocation sequence was generated through a computer-generated list and was delivered by a research-team staff member. Assessors who conducted outcome assessments were blind to group allocation. Baseline assessment, which included demographics, anthropometrics, cognitive function, and physical performance, was completed in a research laboratory at the Shanghai University of Sport. Intervention began within 1 week after the baseline assessment was completed.

Intervention

Intervention group

The protocol used in this study was based on a pilot study in which we showed that momentum-based dumbbell training was safe and suitable for healthy middle-aged and older adults, and improved their mobility, balance, well-being, and sleep quality.[20] Participants in the DTG participated three times per week over 12 weeks in a 60-minute momentum-based dumbbell-training class. All classes were conducted at local senior centers.

The momentum-based dumbbell is a handheld device with two built-in eccentric pendulums (~9 cm in length) at each end. Each dumbbell is 32 cm in length, 22 cm in diameter, and weighs 1.92 kg. Both the size and weight of the dumbbell were fixed for all participants.[26]

The dumbbell training involved instructor-led handheld dumbbell-spinning exercises performed on the front part or lateral side of the body (Figure 1). Specifically, the spinning motion was done in different directions (eg, clockwise and counterclockwise, forward and backward) and body sides (front, Figure 1A and B; left/right, Figure 1C and D). Each individual spinning exercise lasted 1–2, minutes with repetitions set at 4–5 minutes. The initial exercise sessions focused on acclimatizing participants to the movement forms, and followed an easy–difficult progression of short duration (1 minute) with multiple rest breaks. Exercises progressed to longer intervals (1.5–2 minutes), with a 1-minute break between each exercise set. The level of exercise difficulty was tailored to the capabilities of participants. Once most of the participants had mastered the movement, a different movement with a new position or spinning direction and longer exercise duration was adopted to increase the challenge.

Each training session began with 5 minutes of warm-up involving light stretching of the major upper- and lower-extremity muscles, followed by 50 minutes of dumbbell-spinning exercises and a 5-minute cooldown period. Intervention sessions were delivered by two physical education students who were trained by a master instructor involved in the design and training protocol of the intervention.

Control group

The study used a passive control condition in which participants were instructed to maintain a regular lifestyle routine without starting any new exercise activities.

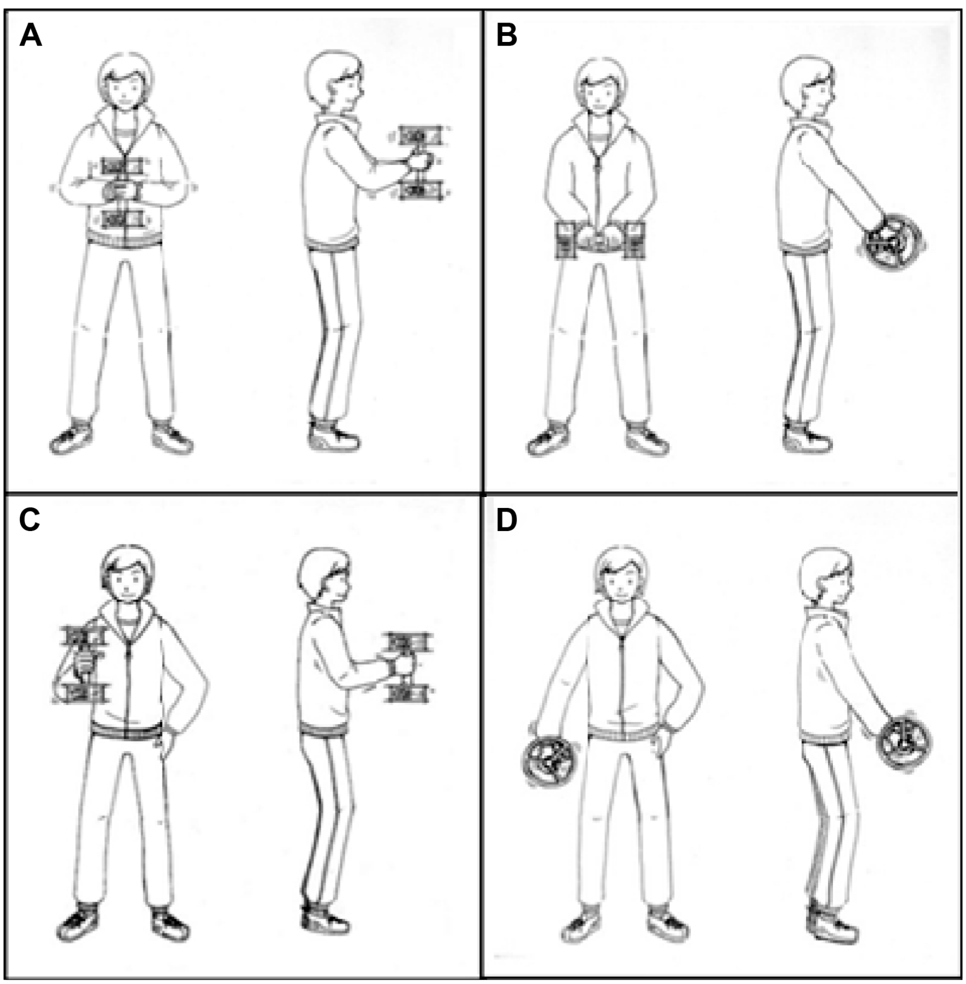

Figure 1 Pictorial representation of dumbbell spinning.

Notes: (**A**) Spinning motion in front of the body, dumbbell in a vertical position (in either clockwise or counterclockwise direction); (**B**) spinning motion in front of the body, dumbbell in a horizontal position (in either forward or backward direction); (**C**) spinning motion on the side of the body, dumbbell in a vertical position (in either clockwise or counterclockwise direction); (**D**) spinning motion on the side of the body, dumbbell in a horizontal position (in either clockwise or counterclockwise direction).

Measures

Primary outcomes

The study had three primary outcome measures, each of which is described in the following paragraphs.

The Chinese version[27] of the Alzheimer's Disease Assessment Scale – Cognitive subscale (ADAS-Cog)[28] was used to assess global cognitive function. The ADAS-Cog consists of 12 cognitive tests evaluating memory, language, praxis, and attention. ADAS-Cog scores ranged from 0 to 75, with higher scores indicating greater severity of CI. In this study, 12-week test–retest reliability was 0.60, with 91.9% sensitivity and 89.5% specificity.[29]

The Trail Making Test part B (TMT-B; Chinese version) was used to assess executive function.[29,30] The TMT-B is a time-based test (in seconds) that requires participants to track letters and numbers alternately (eg, 1, A, 2, B, 3, C). The 12-week test–retest reliability was 0.83, with 87% sensitivity and 90% specificity.[29]

The Digit Span Test – forward (DST-F; Chinese version) and DST – backward (DST-B; Chinese version) were used to assess immediate memory and attention.[29] During each test, participants were asked to recall the numbers in forward order (DST-F) or in backward order (DST-B), which were presented at the rate of one every second. The 12-week test–retest reliability for the two tests was 0.80 and 0.73, respectively, with 46% sensitivity (77% specificity) and 77% sensitivity (78% specificity),[29] respectively.

Secondary outcomes

There were three secondary outcome measures used. The Timed Up and Go (TUG) test was used to assess functional mobility. Participants were asked to stand up from a chair, walk 3 m, turn around, and return to the chair.[31] The 12-week test–retest reliability for this test was 0.76, with 87% sensitivity and 100% specificity.[32]

The functional reach test was used to assess forward stability. Participants were asked to reach forward as far as possible while maintaining their balance without moving their feet.[33] The 12-week test–retest reliability for this test was 0.72, with 62% sensitivity and 92% specificity.[32]

The Activities-Specific Balance Confidence scale assesses participants' perceived confidence in performing balance-related activities.[34] Participants were required to rate their confidence in performing each activity without falling on a 1–5 scale, with 1 indicating "not at all confident" and 5 indicating "completely confident". The 12-week test–retest reliability for this test was 0.83, with 65% sensitivity and 77% specificity.[35]

Statistical analysis

Data were analyzed using intent to treat. Baseline characteristics of the study participants were analyzed using analysis of variance for continuous variables and a χ^2 test for categorical variables. Repeated-measure analysis of variance (group × time) was performed to assess the effects of intervention on cognitive function and physical performance. Important covariates, such as age, sex, education, and health status, were included in the initial analyses. Because results were not altered, the final results were based on unadjusted model testing. An α-level of 0.05 was considered statistically significant. Data analyses were performed using SPSS software (version 20.0; IBM Corporation, Armonk, NY, USA).

Sample size

We calculated that a sample size of 40 participants would provide 80% power (at a two-tailed α-level of 0.05) for detecting differences between groups for an effect size of 0.4 in the ADAS-Cog.[36] Assuming a 10% attrition rate, the study recruited a total of 44 participants (22 per group).

Results

Sample characteristics

A total of 220 individuals were screened. Of these, 175 were excluded for such reasons as not meeting eligibility criteria, being unwilling to participate, or being unavailable due to time conflicts. A final pool of 45 qualified individuals were randomized, with 22 assigned to DTG and 23 assigned to CG (Figure 2). Demographic, anthropometric, cognitive, medication, and comorbidity characteristics of the participants at baseline are shown in Table 1. There were no significant differences between the two groups with regard to baseline descriptors ($P>0.05$).

Compliance and adverse events

One participant in the DTG dropped out due to family-related issues and two dropped out in the CG for reasons related to health and traveling; 42 participants completed the 12-week intervention. The average attendance for the DTG was 31 sessions (of 36 total, range 24–36 sessions). There were no adverse events observed during the course of intervention.

Change in primary outcomes

At the end of the 12-week intervention, participants in the DTG showed significant improvement in the ADAS-Cog ($F=6.95$, $P=0.012$) compared to those in the CG (Table 2). Participants in the DTG exhibited a significant pre- to

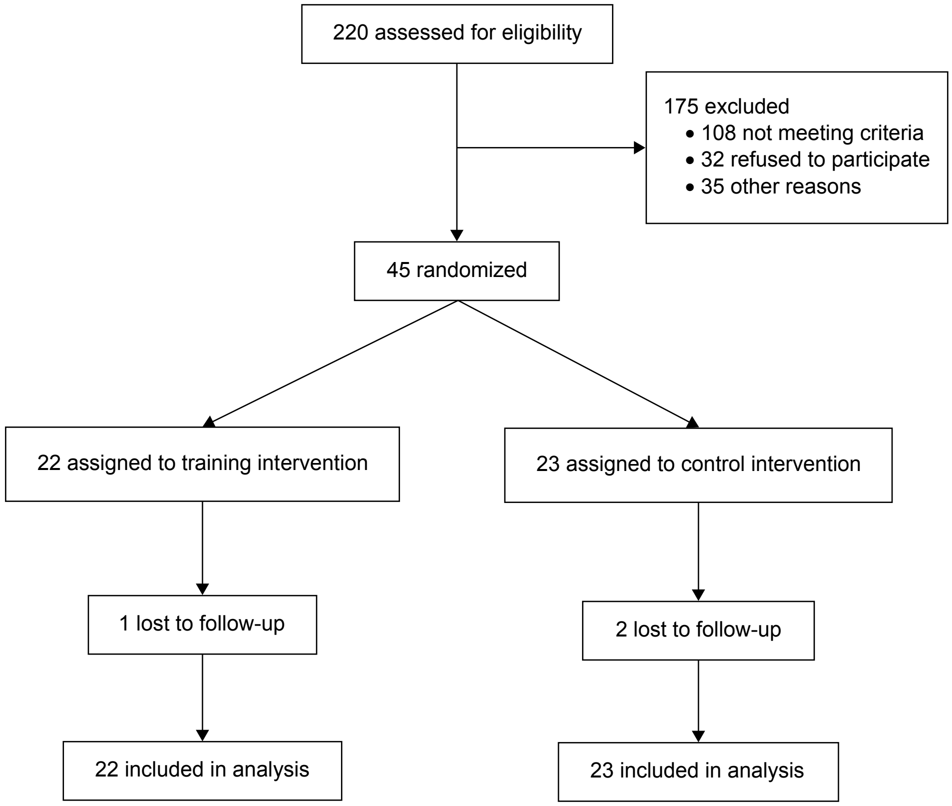

Figure 2 Flowchart of participants from screening to completion of the study.

postintervention improvement in TMT-B (t=3.42, P=0.003) and DST-B (t=–2.41, P=0.025) scores. However, there was a significant within-group pretest–posttest change in TMT-B scores (t=3.14, P=0.005) observed in the CG.

Change in secondary outcomes

Compared to those in the CG, participants in the DTG showed significant improvement in the TUG test (F=4.34, P=0.043). There was no between-group difference in other outcomes (Table 3).

Table 1 Baseline characteristics of trial participants

Variable	Mean (SD)		*P*-value
	DTG (n=22)	CG (n=23)	
Age (years)	69.00 (3.83)	70.43 (5.53)	0.320
Female, n (%)	16 (72.7)	16 (69.6)	0.815*
Education (years)	9.82 (2.75)	9.52 (2.61)	0.713
BMI (kg/m^2)	24.75 (3.44)	23.90 (2.58)	0.352
MMSE (0–30)	27.23 (1.63)	26.43 (2.00)	0.153
MoCA (0–30)	20.59 (2.92)	20.96 (2.70)	0.665
Medication use (0–23)[a]	0.77 (0.61)	0.70 (0.76)	0.712
Comorbidities (0–8)[b]	1.27 (0.83)	1.48 (1.04)	0.468

Notes: [a]Measured on 23 medical conditions (eg, heart disease, stroke, diabetes, depression, cancers); [b]measured on eight categories of comorbid conditions (eg, neurological, psychiatric/mood, heart/circulation, pulmonary); *χ^2 test.
Abbreviations: BMI, body mass index; CG, control group; DTG, dumbbell-training group; MMSE, Mini-Mental State Examination; MoCA, Montreal Cognitive Assessment; SD, standard deviation.

Discussion

In this study, we explored the potential health benefit of a novel, momentum-based dumbbell-training intervention on cognitive function in older adults with MCI. The results indicated that compared to a control condition, a 12-week dumbbell-training intervention significantly improved cognition, as indicated by the positive change in the ADAS-Cog score. Though no between-group difference was observed, there was a significant within-group change (improvement) in TMT-B and DST-B measures, indicating a positive trend in these domain-specific cognitive measures. Compared to those in the CG, the DTG participants showed a concomitant improvement in the mobility measure of the TUG test. The intervention was shown to have satisfactory compliance, as indicated by the low attrition rate (<5%), good attendance rate (mean 31 sessions), and no adverse events. These observations collectively suggest the feasibility of implementing the novel intervention in a community setting and the safety in performing momentum-based dumbbell-spinning exercises with older adults with MCI.

Table 2 Effect of intervention on cognitive function (n=45)

Variable	Mean (SD)				Mean difference from baseline (95% CI)		Group difference at 12 weeks	
	Baseline		After intervention					
	DTG	CG	DTG	CG	DTG	CG	*F*	*P*-value
ADAS-Cog (0–75)	10.23 (3.13)	10.94 (5.68)	7.85 (2.80)	12.87 (4.80)	−2.39 (−3.59 to −1.18)*	1.93 (−0.58 to 4.44)	6.953	0.012†
TMT-B (seconds)	128.77 (69.49)	159.17 (81.48)	95.45 (45.00)	117.85 (54.01)	−33.32 (−53.61 to −13.04)*	−41.33 (−68.60 to −14.05)*	2.092	0.155
DST-F[a]	7.27 (1.38)	7.48 (1.44)	7.41 (1.44)	7.65 (1.61)	0.14 (−0.43 to 0.71)	0.17 (−0.31 to 0.66)	0.313	0.579
DST-B[a]	3.41 (0.59)	3.78 (0.85)	3.82 (0.91)	4.00 (1.13)	0.41 (0.06–0.76)*	0.22 (−0.17 to 0.61)	1.410	0.242

Notes: *Significant difference within group when compared with baseline; †significant difference between groups (DTG and CG) and time (before and after intervention); [a]score was the sum of the number of correct responses.
Abbreviations: ADAS-Cog, Alzheimer's Disease Assessment Scale – Cognitive subscale; CG, control group; CI, confidence interval; DST-B, Digit Span Test – backward; DST-F, DST – forward; DTG, dumbbell-training group; SD, standard deviation; TMT-B, Trail Making Test part B.

Table 3 Effects of intervention on physical function (n=45)

Variable	Mean (SD)				Mean difference from baseline (95% CI)		Group difference at 12 weeks	
	Baseline		After intervention					
	DTG	CG	DTG	CG	DTG	CG	*F*	*P*-value
TUG (seconds)	8.00 (1.23)	8.45 (1.47)	7.29 (0.77)	8.10 (1.01)	−0.71 (−1.14 to −0.27)*	−0.35 (−0.86 to 0.15)	4.341	0.043†
FR (cm)	20.48 (7.02)	18.90 (6.88)	23.17 (8.53)	20.77 (7.00)	2.69 (−0.67 to 6.05)	1.87 (−0.89 to 4.63)	1.056	0.310
ABC (0–100%)	94.50 (6.93)	94.83 (7.22)	93.55 (10.66)	95.78 (6.51)	−0.95 (−4.39 to 2.48)	0.96 (−0.98 to 2.89)	0.344	0.561

Notes: *Significant difference within group when compared with baseline; †significant difference between groups (DTG and CG) and time (before and after intervention).
Abbreviations: ABC, Activities-Specific Balance Confidence; CG, control group; CI, confidence interval; DTG, dumbbell-training group; FR, functional reach; SD, standard deviation; TUG, Timed Up and Go.

Results from this pilot study support growing evidence that shows physical activity or exercise benefits cognitive function in older adults with MCI.[13–17,37] The finding on the improved ADAS-Cog scores is consistent with previous exercise-based interventions involving home-based aerobic[13] and multimodal exercises.[14] To the best of our knowledge, this is the first time that a momentum-based dumbbell-training approach has been used to target change in cognition function. Although the study was exploratory in nature, the findings suggest that dumbbell training is potentially beneficial and may be considered an exercise modality for preventing decline in cognitive function or delaying the onset of dementia in older adults with MCI.

In addition to demonstrating improvement in cognitive measures, the study also showed improved functional mobility, as measured by the TUG test. This finding may be attributed to the fact that dumbbell training is considered a strength-based exercise modality, which may have an impact on lower-limb strength, control of center of mass, and coordination. This may in turn help promote functional activities (ie, sit-to-stand, walking, turning, and stand-to-sit) that are relevant to older adults' activities of living. To ensure the relevance of the training to promoting healthy aging, future studies should consider assessing change in cognitive function in relation to change in physical performance-based outcomes.

Although the mechanism by which the intervention resulted in the positive change in cognitive function is unclear (apart from the need to engage physically in resistance-based dumbbell-spinning exercises), the variation in position changes and movement configurations during the dumbbell-training sessions engages participants in several features pertaining to cognition, such as spatiotemporal orientation, selective attention, and executive control. Integrating motor and cognitive challenges into the multitasking exercise routine may have driven the change in cognitive function among the dumbbell-training participants. Future studies should further examine the potential value of this modality by integrating measures of cognition, sensory, and biomechanical characteristics (eg, kinematics and kinetics) to gain insight into how the momentum-based exercise is able to elicit exercise-induced change in cognitive function.

A major strength of the study is the novelty of using a dumbbell-spinning exercise intervention to evaluate change in cognitive function. However, the study has at least two notable limitations. First, the study used a passive control group. It is thus possible that the positive findings observed in the exercise group may have been due in part to extensive contact time with or attention received from the intervention staff, and/or the Hawthorne effect. Future studies should establish a better choice of a control condition to ensure comparable contact time or attention control. Second, although participants were selected based on some established cognitive measures, they were relative healthy and physically mobile, which could explain the relatively small effect observed.

In conclusion, results from this preliminary study demonstrated that a 12-week, momentum-based dumbbell-training intervention improved cognitive function, especially global cognitive function, in older adults with MCI. Given the promising results, future studies should evaluate the efficacy of this novel exercise modality in improving specific dimensions of cognitive function, and (using a longer follow-up time) examine the sustainability of its training effects.

Acknowledgments

The authors would like to express their gratitude to all the volunteers who participated in this study, and to Ms Xiaodan Li and Mr Pei Ma for teaching and instructing the intervention classes. This study was supported by the National Natural Science Foundation of China (11372194), the Science and Technology Commission of Shanghai (14DZ1103500), and the Education Commission of Shanghai (15cxy46).

Disclosure

The authors report no conflicts of interest in this work.

References

1. World Health Organization. *Dementia: A Public Health Priority*. Geneva: WHO; 2012.
2. Song Y, Wang J. Overview of Chinese research on senile dementia in mainland China. *Ageing Res Rev*. 2010;9 Suppl 1:S6–S12.
3. Brookmeyer R, Johnson E, Ziegler-Graham K, Arrighi HM. Forecasting the global burden of Alzheimer's disease. *Alzheimers Dement*. 2007; 3(3):186–191.
4. Petersen RC, Smith GE, Waring SC, Ivnik RJ, Tangalos EG, Kokmen E. Mild cognitive impairment: clinical characterization and outcome. *Arch Neurol*. 1999;56(3):303–308.
5. Petersen RC, Thomas RG, Grundman M, et al. Vitamin E and donepezil for the treatment of mild cognitive impairment. *N Engl J Med*. 2005;352(23):2379–2388.
6. Feldman HH, Ferris S, Winblad B, et al. Effect of rivastigmine on delay to diagnosis of Alzheimer's disease from mild cognitive impairment: the InDDEx study. *Lancet Neurol*. 2007;6(6):501–512.
7. Thal LJ, Ferris SH, Kirby L, et al. A randomized, double-blind, study of rofecoxib in patients with mild cognitive impairment. *Neuropsychopharmacology*. 2005;30(6):1204–1215.
8. Doi T, Makizako H, Shimada H, et al. Objectively measured physical activity, brain atrophy, and white matter lesions in older adults with mild cognitive impairment. *Exp Gerontol*. 2014;62:1–6.
9. Makizako H, Liu-Ambrose T, Shimada H, et al. Moderate-intensity physical activity, hippocampal volume, and memory in older adults with mild cognitive impairment. *J Gerontol A Biol Sci Med Sci*. 2014; 70(4):480–486.

10. Tanigawa T, Takechi H, Arai H, Yamada M, Nishiguchi S, Aoyama T. Effect of physical activity on memory function in older adults with mild Alzheimer's disease and mild cognitive impairment. *Geriatr Gerontol Int*. 2014;14(4):758–762.
11. Jedrziewski MK, Ewbank DC, Wang H, Trojanowski JQ. Exercise and cognition: results from the National Long Term Care Survey. *Alzheimers Dement*. 2010;6(6):448–455.
12. Grande G, Vanacore N, Maggiore L, et al. Physical activity reduces the risk of dementia in mild cognitive impairment subjects: a cohort study. *J Alzheimers Dis*. 2014;39(4):833–839.
13. Lautenschlager NT, Cox KL, Flicker L, et al. Effect of physical activity on cognitive function in older adults at risk for Alzheimer disease: a randomized trial. *JAMA*. 2008;300(9):1027–1037.
14. Suzuki T, Shimada H, Makizako H, et al. A randomized controlled trial of multicomponent exercise in older adults with mild cognitive impairment. *PloS One*. 2013;8(4):e61483.
15. Suzuki T, Shimada H, Makizako H, et al. Effects of multicomponent exercise on cognitive function in older adults with amnestic mild cognitive impairment: a randomized controlled trial. *BMC Neurol*. 2012;12:128.
16. Cassilhas RC, Lee KS, Fernandes J, et al. Spatial memory is improved by aerobic and resistance exercise through divergent molecular mechanisms. *Neuroscience*. 2012;202:309–317.
17. ten Brinke LF, Bolandzadeh N, Nagamatsu LS, et al. Aerobic exercise increases hippocampal volume in older women with probable mild cognitive impairment: a 6-month randomised controlled trial. *Br J Sports Med*. 2015;49(4):248–254.
18. Khan KM, Thompson AM, Blair SN, et al. Sport and exercise as contributors to the health of nations. *Lancet*. 2012;380(9836):59–64.
19. Sun MY. Effect of inertial barbell training on transversus abdominis muscle activity. *China Sport Sci Technol*. 2013;49(1):140–145.
20. Lü J, Liu Y. Effect of momentum-based dumbbell training program on physical performance in middle-aged and elderly adults: a feasibility study. Poster presented at: 17th National Conference on Sports Biomechanics Academic Exchange; September 29, 2014; Dalian, People's Republic of China.
21. 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):189–198.
22. Zhang MY, Katzman R, Salmon D, et al. The prevalence of dementia and Alzheimer's disease in Shanghai, China: impact of age, gender, and education. *Ann Neurol*. 1990;27(4):428–437.
23. Nasreddine ZS, Phillips NA, Bédirian V, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc*. 2005;53(4):695–699.
24. Lu J, Li D, Li F, et al. Montreal Cognitive Assessment in detecting cognitive impairment in Chinese elderly individuals: a population-based study. *J Geriatr Psychiatry Neurol*. 2011;24(4):184–190.
25. Hill LR, Klauber MR, Salmon DP, et al. Functional status, education, and the diagnosis of dementia in the Shanghai survey. *Neurology*. 1993;43(1):138–145.
26. Liu Y, Lu JQ, inventors; Shanghai University of Sport, assignee. Dumbbell having adjustable inertial resistance load characteristic. United States Patent US 8251878B2. 2012 Aug 28.
27. Wang H, Shu L, Si T, Tian CH, Zhang HY. [Validity and reliability of Chinese version of Alzheimer's Disease Assessment Scale]. *Chin J Clin Psychol*. 2000;8(2):89–92. Chinese.
28. Rosen WG, Mohs RC, Davis KL. A new rating scale for Alzheimer's disease. *Am J Psychiatry*. 1984;141(11):1356–1364.
29. Guo Q, Hong Z. *Neuropsychological Assessment*. Shanghai: Shanghai Science and Technology Press; 2013.
30. Strauss E, Sherman EM, Spreen O. *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary*. 3rd ed. New York: Oxford University Press; 2006.
31. Mathias S, Nayak U, Isaacs B. Balance in elderly patients: the" get-up and go" test. *Arch Phys Med Rehabil*. 1986;67(6):387–389.
32. Thomas JI, Lane JV. A pilot study to explore the predictive validity of 4 measures of falls risk in frail elderly patients. *Arch Phys Med Rehabil*. 2005;86(8):1636–1640.
33. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. *J Gerontol*. 1990;45(6):M192–M197.
34. Powell LE, Myers AM. The Activities-Specific Balance Confidence (ABC) scale. *J Gerontol A Biol Sci Med Sci*. 1995;50A(1):M28–M34.
35. Cattaneo D, Regola A, Meotti M. Validity of six balance disorders scales in persons with multiple sclerosis. *Disabil Rehabil*. 2006;28(12):789–795.
36. Orrell M, Yates LA, Burns A, et al. Individual Cognitive Stimulation Therapy for dementia (iCST): study protocol for a randomized controlled trial. *Trials*. 2012;13:172.
37. Porto FH, Coutinho AM, Pinto AL, et al. Effects of aerobic training on cognition and brain glucose metabolism in subjects with mild cognitive impairment. *J Alzheimers Dis*. 2015;46(3):747–760.