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The effect of a game training intervention on cognitive functioning and depression symptoms in the elderly with mild cognitive impairment: A randomized controlled trial

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Abstract

Objectives: This study aimed to explore whether game training could improve cognitive functioning and depression symptoms in the elderly affected by mild cognitive impairment (MCI).

Methods: A non-blinded randomized controlled trial was conducted. Participants were 72 patients with MCI and depression from a nursing home in Wuhan. Participants were randomized to either the intervention group or the control group (n = 36 each). The intervention group received regular nursing care plus game training for 50 min, three times per week for 8 weeks, whereas the control group received only regular nursing care during the same research period. Cognitive functioning and depression symptoms were tested in both groups at baseline and at the end of the 8-week intervention. We used the Montreal Cognitive Assessment and the 15-item Geriatric Depression Scale to assess cognitive functioning and depression symptoms, respectively.

Results: The 8-week game training intervention significantly improved the cognitive and depression scores when compared with the control group and baseline scores ($p < 0.05$). No significant difference was observed in the control group ($p > 0.05$).

Conclusions: Our results suggest that the implementation of game training can improve the cognitive functioning and depression symptoms of the elderly with MCI, indicated that can be widely used.

KEYWORDS

depression, game training, MCI, the elderly

1 | INTRODUCTION

The proportion of people aged 60 years and older in the population has been increasing in recent years (Huang et al., 2019; Nayak et al., 2019). The number of people aged 60 years and older was 1 billion in 2019, which is projected to increase to 1.4 billion by 2030 and 2.1 billion by 2050 (World Health Organization, 2018). Mild cognitive impairment (MCI) is a transitional stage between normal aging and dementia in the elderly (Dominguez-Chavez et al., 2019; Edmonds et al., 2019; Petersen et al., 2018) and is believed to be a risk factor for Parkinson's disease (Hoogland et al., 2017). The American Academy of Neurology (AAN) updates its clinical practice

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guidelines for MCI, and epidemiological data have shown that the prevalence of MCI increases with age (Petersen et al., 2018). Researchers have found an overall MCI prevalence of 20.8%, indicating approximately 23.86 million individuals aged 65 years or older suffer from MCI in China (Jia et al., 2014). MCI can easily develop into dementia if there is no active and effective intervention early. Some patients can maintain stability or restore normal cognitive functioning. However, even though some MCI patients have a chance of returning to a normal level of cognitive functioning, the risk of developing dementia remains higher than that of patients who have never been diagnosed with MCI, ranging between 5% and 10% compared with typical older adults (Mitchell & Shiri-Feshki, 2010; Petersen et al., 2018).

MCI does not affect normal life; people can do many things normally and independently (Dominguez-Chavez et al., 2019). But the decline in cognitive function and memory may negatively impact patients' mood, relationships, and treatment compliance (Chandler et al., 2016). One of the most challenging differentials of dementia and cognitive impairment is depression, which may be a risk factor for the progression of MCI to dementia (Jingru, 2018). Depression is a significant mental health problem in the elderly (Gao et al., 2013), while behavioral and psychiatric symptoms are common in patients with MCI. Patients with MCI experience a decline in their cognitive functioning, and awareness of this problem allows for easy reactions with an alteration in mood or behavior (Mirza et al., 2017). This disorder not only brings pain to the patients, but also increases the burden of care and disease, and may even lead to greater dysfunction. A study illustrated that patients with both MCI and depression scored lower on cognitive tests than those with MCI only (Larner, 2019). There is evidence suggesting that depression is a major risk factor for the progression to dementia in subjects with MCI (Gao et al., 2013; Mourao et al., 2016). Moreover, some studies have shown that people with MCI are more likely to have depressive disorders compared with those without MCI (Lyketsos et al., 2002; Mirza et al., 2017).

Currently, intervention strategies for MCI and depression mainly include pharmacological intervention and non-pharmacological intervention (Bingham et al., 2019; Kishita et al., 2019). Some studies have found that donepezil achieved good results in the treatment of MCI (Ji-wei & Jing-kun, 2012; Tong et al., 2013). Bingham reviewed the treatment of depression in older adults with cognitive impairment and ascertained that psychological, behavioral, and some somatic therapies exert positive effects. No evidence supports that antidepressants are effective in treating patients with MCI in the past 4 years (Bingham et al., 2019); two articles (Dudas et al., 2018; Orgeta et al., 2017) found that there was no significant difference between antidepressant and placebo groups on reducing depressive symptoms. Huckans believed that multidimensional interventions could effectively improve cognitive functioning, but the impact on memory functioning was not significant (Huckans et al., 2013). Some studies suggest that exercise interventions, such as extensive aerobic exercise (Devenney et al., 2017), tai chi qigong (Chan et al., 2016), and Baduanjin (Guohua et al., 2017) can improve the level of cognitive functioning of elderly patients with MCI. Cognitive therapy is believed to be an effective treatment method for MCI patients, including group-based training, home-based training (Jeong et al., 2016), and rehabilitation care intervention training such as intellectual game activities (Yanping & Jianxin, 2013). Game training was designed based on the stimulation of the cerebral cortex to improve cognitive functioning of patients and reduce the risk of MCI and depression (Krell-Roesch et al., 2017). Studies have demonstrated video game training can improve the cognitive functioning of the elderly (Anguera et al., 2017; Belchior et al., 2013). However, few studies have focused on other types of game training. Traditional Chinese games and interactive games can train logical thinking and stimulate the cognitive function of patients (Chen & Hongying, 2011; Mei et al., 2017).

Numerous studies have focused on MCI, but little is known about the treatment of patients with MCI who have depression. Studies focusing on the psychological effects of game training on the elderly with MCI are scarce. Improvements in the training of MCI in depression treatment trials will help advance knowledge in this area (Bingham et al., 2019). The objectives of the study were to contribute to the understanding of the effectiveness of game training interventions for elderly individuals with both MCI and depression and provide a scientific theoretical basis and practical implications for health authorities and service agencies.

2 | METHODS

2.1 | Study design

We conducted a two-arm, open-label, randomized controlled trial by enrolling the elderly with MCI from community health centers and nursing homes. The intervention group received game training, while the control group received usual treatment during the research period.

2.2 | Participants

The sample size was calculated using G-power software. We hypothesized that the intervention will have the effect size of 0.7. With a power of 80% and an α of 0.05, 34 subjects for each condition of the study were required. Considering the loss of the sample, 36 subjects for each condition were determined.

The inclusion criterion in the study were (a) being 65 years old or older and independent in daily functioning without severe hearing, vision, and communication impairment; (b) a Montreal Cognitive Assessment (MoCA) score <26; (c) a GDS-15 score ≥8; (d) does not meet the diagnostic criteria for dementia; and (e) signed the informed consent form. Exclusion criteria were (a) having difficulty in moving, (b) a history of serious physical illness, and (c) severe cognitive decline with little independent functioning.

Participants were recruited in person from a nursing home in Wuhan. Recruitment commenced in October 2018 and continued until February 2019. Participants who were interested in this study

were asked to complete our questionnaires to assess their eligibility for participation with the help of our researcher. Participants were assigned according to the alphabetical order of their names and numbered from 1 to 72. Then, they were assigned on a 1:1 basis into the intervention group or the control group per the computer-generated random number table scheme.

2.3 | Intervention program

The game training was conducted by an undergraduate nursing student who had studied elderly nursing courses and game training. The intervention group received a series of game training three times per week for 8 weeks. The control group received usual nursing care, such as health education, during the 8-week research period. Due to ethical considerations, the elderly in the control group will receive game training after study completion. All games included themes specific to MCI. Group gaming training programs include group games (e.g., mental activities, memory games such as remember the sequence and color of the balls, coordination games, and emotional games), solitaire games (e.g., poker, puzzles, and board games), and partner games. Traditional games are comprehensible to participants who can exercise cognitive functioning and reactive functioning. Simultaneously, group games help the elderly improve their relationships and emotional states. The poker game is easy to learn and has little time and space limitations, while also having the characteristics of teamwork and competition that stimulate the attention and instant memory of the elderly (Jiaying & Xueping, 2016).

Each weekly session followed a specific schedule. The first week focused on getting to know each other and developing friendships by name games, training the memory of the elderly at the same time. The next 3 weeks aimed to train the elderly's reaction by a Chinese letter game and number guess game. The fifth and sixth weeks used teamwork games to improve the relationships of the elderly. The last 2 weeks were devoted to poker and board games, which discipline thinking and produce new information.

2.4 | Statistical analysis

The first author and one undergraduate student who had received training previously accomplish the data collection. Intention-to-treat analysis was performed by using the imputation method. The missing data were replaced the mean scores. All data were analyzed using the Statistical Package for Social Sciences (SPSS) software (version 23.0 for Windows, SPSS Inc.). The significance level was set at $p < 0.05$. Descriptive statistics were calculated to examine the baseline characteristics. The independent sample *t*-test was used to assess differences in the baseline variables. To determine the efficacy of the intervention, we analyzed the change from baseline to post-intervention of the game training group and control group by using one-way ANOVA and Wilcoxon sign-rank test because of the unequal variance.

2.5 | Outcomes

Two outcomes were measured in this study, and assessments were performed at baseline and post-intervention. The first outcome cognitive functioning was measured by the Chinese version of the MoCA which has good internal consistency which is a 30-item instrument with a higher score indicating better cognitive functioning, and a score below 26 indicating a low level of cognitive functioning. The Cronbach's α coefficient is 0.818 (Zhang & Liu, 2007). Depression symptoms as the second outcome were measured by the Chinese version of the 15-item Geriatric Depression Scale (GDS-15), which is a self-report instrument that assesses depression symptoms in the elderly. The specificity is 0.88 and the internal consistency Cronbach's α coefficient is 0.82 (Mei, 1999; Tang, 2013). The score ranging from 0 to 15, with a score greater than 8 indicating depression symptoms. Higher scores indicate greater risk for depression.

2.6 | Ethical considerations

This study was approved by the Wuhan University Institutional Review Board. The following ethical principles were followed throughout the intervention research process: confidentiality, respect, and benefit. We still paid attention to safety issues though none of the studies on cognitive and depression game training reviewed found adverse effects.

3 | RESULTS

A total of 261 questionnaires were distributed among the eligible elderly groups in Wuhan and 240 valid questionnaires were analyzed. In total, 72 elderly people who met the inclusion criteria and volunteered to participate in the study were selected (Figure 1). More than 95% of the participants attended all sessions while few of them were absent one or two times due to physical reasons in the intervention group and all the participants were not being treated for depression or cognitive impairments with medication/psychotherapy during the intervention time.

3.1 | Sociodemographics

Table 1 shows the sociodemographic characteristics of the participants. The average age of participants in the intervention and control group was 75.42 ± 4.576 and that of the control group was 73.44 ± 4.884. Female patients in the two groups accounted for the majority of the participants (about two-thirds) and more than half of them were single.

There was no statistically significant difference in the general demographic data and the MoCA and GDS-15 scores baseline of the control and intervention groups ($p > 0.05$), which can be compared directly.

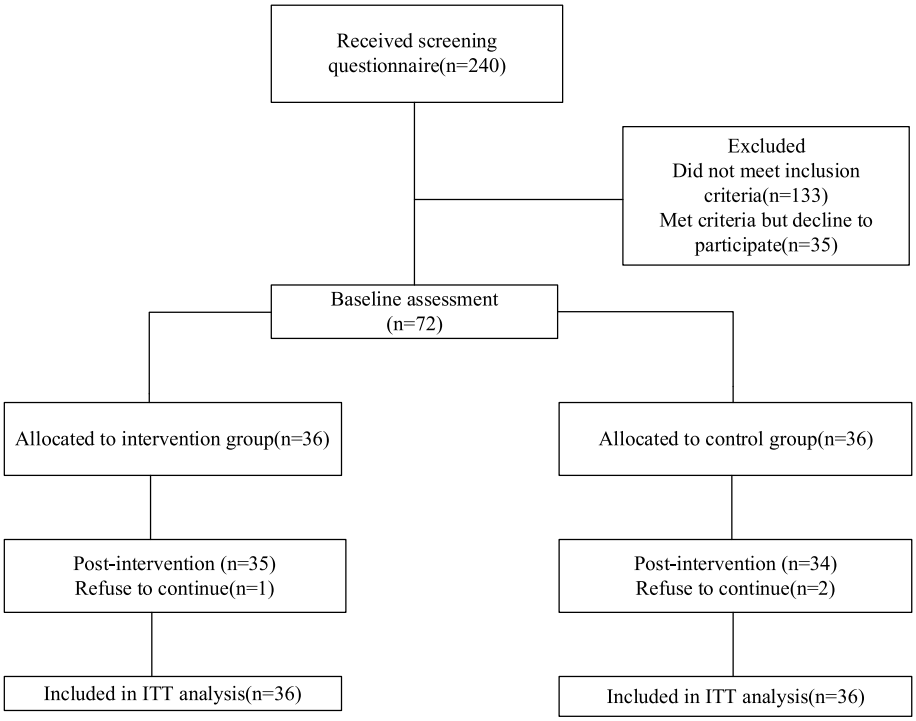

FIGURE 1 Participants recruitment and flow diagram of mild cognitive impairment patients with depression in the treatment of game training

3.2 | Primary outcome: cognitive function

Table 2 shows the MoCA score from baseline to post-intervention of the intervention group and the control group. We found statistically significant differences in the intervention group ($p < 0.05$), while there was no statistically significant difference in the control group. In the intervention group, the average score of cognitive functioning of the elderly people showing a statistically significant increase. The control group score also improved, but the statistical difference was not significant ($p > 0.05$). We use the omega squared (ω^2) and the correction for eta squared (η^2) to show the effect size of the group comparison. The effect size (ω^2) of the group comparison is 0.075.

Each entry score improved during the intervention, while the scores of four entries in the MoCA questionnaire were higher in the intervention group, including Naming, Attention, Language, and Delayed recall, which were statistically significant ($p < 0.05$). The average score in Language improved significantly ($p < 0.01$), indicating that game training yielded great improvement. However, two entries, namely Visuospatial/Executive and Orientation, did not show significant differences in the intervention group. At the same time, the control group showed a significant improvement in Naming, while the other entries did not differ significantly.

3.3 | Second outcome: depression symptom

After 8 weeks of game training in the intervention group, the cognitive and depression scores improved, and there was a statistically significant difference compared with the control group and baseline ($p < 0.05$). In contrast, the control group showed no significant difference ($p > 0.05$). Both the intervention and control groups showed a decrease in the GDS-15 score (Table 3), while the intervention group reported a significant improvement in their depression symptoms, and the control group did not differ significantly ($p > 0.05$). The effect size (ω^2) of group comparison is 0.239.

Only 5 of the 15 items were scored lower by the intervention group, "Do you often get bored?" "Are you in good spirits most of the time?" "Do you prefer to stay at home, rather than go out and do things?" "Do you feel you have more problems with memory than most?" and "Do you feel pretty worthless the way you are now?" were considered statistically significant ($p < 0.05$). In contrast, "Have you dropped many of your activities and interests?" and another nine items did not show a significant difference ($p > 0.05$). No significant differences were observed in the control group.

4 | DISCUSSION

Our study found that game training is efficient for the elderly with MCI suffering from depression. Game training can improve cognitive function and it is an interesting and easy intervention for the elderly to enrich their daily lives and improve their depressive states.

The MoCA score of the elderly in the intervention group was significantly higher than at the baseline after 8 weeks of game training. Brain function and dysfunction are influencing factors of cognitive impairment that may lead to MCI. Cognitive games have

TABLE 1 The characteristics of the elderly in the intervention group and the control group at baseline

Variables	Intervention group (n = 36)	Control group (n = 36)	p-Value
Age (years) mean ± SD	75.42 ± 4.576	73.44 ± 4.884	0.081
Gender			0.623
Male	11 (30.6%)	13 (36.1%)	
Female	25 (69.4%)	23 (63.9%)	
Education			0.743
Primary school and no degree	14 (38.9%)	14 (38.9%)	
High school or polytechnic	17 (47.2%)	19 (52.8%)	
University degree	5 (13.9%)	3 (8.4%)	
Marital status			0.074
Married	13 (36.1%)	5 (13.9%)	
Single	23 (63.9%)	31 (86.4%)	
Smoking[a]	9 (25%)	8 (22.2%)	0.785
Drinking	3 (8.3%)	2 (5.6%)	0.649
Sleep status			0.103
Below 3 h	3 (8.3%)	7 (19.4%)	
3–6 h	11 (30.6%)	13 (36.1%)	
6 h above	22 (61.1%)	16 (44.4%)	
Learning or reading			0.555
Always	6 (16.7%)	6 (16.7%)	
Little	22 (61.1%)	25 (69.4%)	
Never	8 (22.2%)	5 (13.9%)	
Exercise			0.459
Always	3 (8.3%)	1 (2.8%)	
Little	24 (66.7%)	31 (86.1%)	
Never	9 (25%)	4 (11.1%)	
Chronic disease	25 (69.4%)	24 (66.7%)	0.804
Family history	21 (58.3%)	14 (38.9%)	0.102

[a]The smoking and drinking variables only reflect current status.

TABLE 2 The distribution of the MoCA scores of the intervention group and the control group

MoCA	Intervention group (M ± SD)	Control group (M ± SD)	F[a]	p
Baseline	20.56 ± 1.443	19.64 ± 2.416	3.820	0.055
Post-intervention	20.97 ± 1.362	19.92 ± 2.048	6.631	0.012
Z-value[b]	−2.950	−0.739		
p-Value	0.003	0.460		

Abbreviation: MoCA, Montreal Cognitive Assessment.

[a]F: One-way ANOVA.

[b]Z value: Wilcoxon analysis.

been used in studies attempting to enhance cognition in the elderly by stimulating the patients' brain plasticity (Scase et al., 2018; Stavros et al., 2010). Game training has a stimulating effect on memory and communication in the elderly with MCI (Huckans et al., 2013). The elderly can use the commands issued by the game to stimulate the brain to think and focus on responding to the commands. Researchers have explored computer-based cognitive game training for the elderly with MCI, finding that it helped improve attention abilities and memory (Stavros et al., 2010), while another study demonstrated that cognitive game training, including adaptive games, may change the brain hippocampal functioning and improve memory (Rosen et al., 2011). As intellectual activities, mental game activities such as number games and picture pointing games impel the

TABLE 3 The distribution of the GDS-15 scores of the intervention group and the control group

GDS-15	Intervention group ($M \pm SD$)	Control group ($M \pm SD$)	F[a]	p
Baseline	8.94 ± 0.860	8.61 ± 0.803	3.890	0.094
Post-intervention	7.33 ± 0.828	8.36 ± 0.961	23.638	<0.001
Z-value[b]	−5.020	−1.767		
p-Value	<0.001	0.077		

Abbreviation: GDS-15, Geriatric Depression Scale.

[a]F: One-way ANOVA.

[b]Z-value: Wilcoxon analysis.

brain to think, which can improve the participants' cognitive functioning (Barnes, 2013). Manera et al. examined the efficiency and acceptability of the "kitchen and cooking" game for the elderly with MCI or dementia (2015). The cited study found that the "kitchen and cooking" game stimulates executive functions. However, Hughes and colleagues found that interactive video game training improved cognitive function and physics, but the difference was not statistically significant (Hughes et al., 2014). The participants achieved the goal of promoting cognitive rehabilitation by concentrating and cooperating with team members to complete the task. Poker, aeroplane chess, and some other board games helped the elderly learn to accept something new, while colorful chess and cards may stimulate the elderly's vision. A report identified that cognitive stimulation and training exerts positive effects on cognitive functioning and physical functioning, but still lacks consistency and sufficient evidence, warranting more in-depth research (Patnode et al., 2020). Meanwhile, Burgio et al. found that the "Game of Dice Task" can help the elderly with MCI to make decisions and improve their executive ability (Burgio et al., 2018).

The incidence of dementia is high, and its progression is rapid. Studies have shown that depression, anxiety, and other negative mental health conditions can significantly reduce the cognitive functioning of elderly individuals with MCI (Gabryelewicz et al., 2004). The implementation of interventions to delay the progression of cognitive impairment and depressive states in the elderly is particularly important. After the 2-month game training intervention, depression symptoms of the MCI elderly improved. Depression was prevalent in the two groups before the intervention, with symptoms including dissatisfaction with one's living environment, feelings of helplessness, feelings of emptiness, and so on. Functional ability in daily life is an important factor affecting the level of depression; the reason may be that elderly patients with MCI who have poor physical functioning and low levels of self-care are prone to self-denial and less experience of the joys of life and self-existence (Hui-ying et al., 2012). In our study, we found that the elderly with MCI prefers to stay in the room. It may due to a monotonous lifestyle and people's attitude toward nursing homes. Elderly people who have difficulties taking care of themselves and live alone choose to live in nursing homes, which exacerbates depression symptoms (Shuya & Zheng, 2018). Games such as "pass the parcel," "Truth or dare," and "building lego blocks" help the elderly open up and talk about their troubles, thereby enhancing the relationships between them and, in turn, improving their depressive states. Encouraging the elderly to speak out helps to vent their negative emotions. Cohen et al. put all participants on the same team with a colorful broad game, finding that their emotion scales had significantly improved (Changqing & Hui, 2020; Cohen et al., 2008), which indicates that game therapy has a positive effect on patients' emotions. Our results are similar to those of a study focusing on music game exercise therapy (Qin et al., 2020). The mental health state of the elderly, including their emotional pleasure, and their overall cognitive functioning are improved during the music game.

Game training therapy has a positive effect on improving the cognitive functioning of the elderly. At the same time, it also encourages elderly patients to take the initiative to participate in treatment (Mei et al., 2017). A growing number of studies suggest that games designed for older people can improve cognitive performance, and the interaction during games can also enhance communication and reduce loneliness among older people. However, most of the existing studies only focus on one aspect of MCI or depression in the elderly. Few studies have combined the two, and there is still a lack of comprehensive intervention programs. Researches on the elderly with MCI mainly focused on the exercise of cognitive functioning. There are few studies on multidimensional interventions, such as interventions for depression symptoms. In addition, there are few studies on game training for the MCI elderly. Our research enriches existing research on this treatment method and the daily lives of the elderly. Due to various factors, our study has some limitations that could be addressed in future research. First, the sample of this study is relatively small in size and mainly comes from Wuhan City. The results are only applicable to the cognitive status and current status of depression symptoms in the elderly of this region; thus, the generalization of the research conclusions needs to be improved. The second limitation is the lack of long-term follow-up and the assessment of quality of life. Some entries of the two assessment scales did not show significant differences, which may be because the duration of game training was only 8 weeks and the effects could not be fully realized. On the other hand, the study did not include an evaluation of whether the improvements obtained after 8 weeks persisted over a more extended period of time, and the long-term effects of game training could not be evaluated. And because of the lack of human and material resources support, it was difficult to intervene in game

for everyone individually, so we did all the intervention by the type of group to facilitate the implementation and management. In the future, follow-up and post-testing can be conducted after 3 months, 6 months, or longer to further explore the significance of the intervention and whether it has a continuous long-term effect on the elderly with MCI.

5 | CONCLUSIONS

Depressive symptoms negatively affect cognitive functioning and active measures should be taken immediately to prevent or delay the development of dementia. The high prevalence of MCI in China imposes a heavy burden and requires appropriate public measures. The current study provides evidence that game training is promising for improving cognitive abilities, emotional states, and quality of life in patients with MCI who are at high risk of developing Alzheimer's disease. In addition, game training provides the possibility of reducing the social burden.

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AUTHOR CONTRIBUTIONS

Xianwu Luo and Rui Li conceived and designed the study; Bing Xue and Ao Xiao collected and analyzed the data; Bing Xue wrote the draft of the manuscript; and Xianwu Luo and Rui Li critically revised the manuscript. All authors contributed substantially to this work.

CONFLICT OF INTEREST

The authors report no conflicts with any product mentioned or concept discussed in this article.

DATA AVAILABILITY STATEMENT

Data are available on reasonable request to the authors.

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