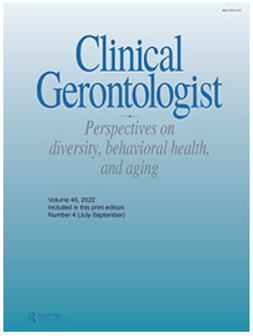

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An Evaluation of the Effects of Active Game Play on Cognition, Quality of Life and Depression for Older People with Dementia

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ABSTRACT

Objectives: This pilot study was intended to evaluate the effects of active game play on cognition, quality of life, and depression for older people with dementia.

Methods: Thirty-eight older people with dementia were recruited. Eighteen people received eight-week active game play using Xbox 360 Kinect. Twenty people received their usual care. The Mini Mental State Examination, Quality of Life-Alzheimer's Disease and Cornell Scale for Depression in Dementia were used to measure the outcomes.

Results: The results showed that there was no significant improvement on the mean scores of Mini Mental State Examination (P = .252), however, the active game play increased the mean score of Quality of Life-Alzheimer's Disease (P = .005), and reduced the mean score of Cornell Scale for Depression in Dementia (P = .001) in comparison with the usual care group.

Conclusions: The study demonstrated that the active game play was effective in improving quality of life and alleviating depression in older people with dementia.

Clinical Implications: Findings highlight the potential for gaming as a non-pharmacological interventions for older people with dementia.

KEYWORDS

Active game play; exergames; cognition; Dementia; non-pharmacological

Background

Dementia represents a collection of symptoms that are caused by brain disorders. It is usually chronic and involves progressive deterioration in cognitive and daily functions ("2019 Alzheimer's disease facts and figures," 2019). Dementia does not only cause difficulty in performing activities of daily living, such as eating, dressing, and toileting (Cornelis, Gorus, Van Schelvergem, & De Vriendt, 2019), but also has a significant impact on the quality of life (Kisvetrová et al., 2021). Behavioral and psychological symptoms of dementia (BPSD) and depression can cause rapid decline in function, earlier institutionalization and increasing mortality (Khundakar & Thomas, 2015). Managing dementia requires substantial amount of human and economic resources worldwide, including medical and nursing care, pharmacological management, and informal daily living care by family members. These impose substantial societal and economic costs (Cantarero-Prieto, Leon, Blazquez-Fernandez, Juan, & Cobo, 2019). Therefore, dementia is a growing public health concern associated with the aging population.

As there is no medical cure to stop or reverse the progress of functional decline in dementia, an increasing scientific and community interest has been focused on non-pharmacological interventions to improve or at least to maintain cognition and quality of life for people with dementia (Cabrera et al., 2015; Oliveira et al., 2015). Neuroplasticity is the ability of the human brain to adapt to environmental changes by modifying neural connectivity and brain function (Knaepen, Goekint, Heyman, & Meeusen, 2010). Studies have indicated that even older people with dementia still maintain a certain level of neural plasticity (Spironelli, Bergamaschi, Mondini, Villani, & Angrilli, 2013). This provides hope to improve their cognition through rehabilitation training (Spironelli et al., 2013).

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Because playing games requires mental concentration, intelligence, memory, and quick reaction (Cohen, Firth, Biddle, Lewis, & Simmens, 2009; Fenney & Lee, 2010), Anguera et al. (2013) suggest that games can be used for cognitive training of people with dementia. Games, in general, are fun and delightful. They can reduce loneliness, invoke a sense of accomplishment, and cultivate positive mood (Lin, Cao, & Gao, 2015; Manera et al., 2015). Recently, there is increasing use of active game play to provide various therapies in virtual environments under simulating conditions. These therapies take the advantages of active games in combining the fun of gameplay with physical exercise (Ackerman, Kanfer, & Calderwood, 2010; Saenz-de-Urturi, Garcia-Zapirain, & Zorrilla, 2014), physical exercise has a therapeutic effect on cognition by delaying hippocampal neurodegeneration in people with Alzheimer's disease (AD) (Huttenrauch et al., 2016; Yu et al., 2014). Moreover, active games provide immediate performance feedback, such as encouragement comments, bonuses; and music, which is interactive and motivational, and active games have the flexibility to offer various activity levels, and allow playing in different postures, either standing, or sitting (Chao, Scherer, & Montgomery, 2015). These make active games suitable for players with different levels of game play experience and physical condition.

There are some pioneer experiments with active game play for people with dementia. For example, Dove et al. (2019) used Xbox Kinect as a group activity for people with dementia, this qualitative study found that people with dementia can learn to play active games and enjoy doing so. Yamaguchi (2011) examined the effects of video-sports games on cognition, visuospatial and constructive functions, and behavior in people with dementia (n = 9). Two types of games were used in their program: one working on the upper limb, another working on the lower limb. The former required a player to catch coins which appeared to be flying out of the screen. The later required a player to move legs to the music rhythm. The gaming was provided once a week for 10 weeks. It was shown that the active game play can lead to improvement in the participant's cognition, visuospatial, and constructive functions. While, the sample size of this study was small (n = 9), the duration of the game session and the baseline characteristics of the participants have not been reported. Swinnen et al. (2021) explored the physical, mental, and cognitive effects of an active game with "Dividat Senso" device in comparison with watching preferred music videos (control group) for people with major neurocognitive disorder living in long-term care facilities. For the experiment period was 8 weeks. The gaming group had improvement in depression than the control group as measured by Cornell Scale for Depression in Dementia (CSDD). Their quality of life was also improved despite the changes did not reach statistically significant level in comparison with the control group as measured by Dementia Quality of Life questionnaire.

Due to poor study design and small sample size in the aforementioned studies, to date, there is a lack of sound evidence to support the positive effects of active game play on cognition, quality of life, and depression for older people with dementia. Therefore, this study aims to close this knowledge gap.

We will test the following hypotheses:

H1: The active game play will result in higher Mini Mental State Examination scores compared to the control group and baseline after 8 weeks.

H2: The active game play will result in lower Cornell Scale for Depression in Dementia scores compared to the control group and baseline after 8 weeks.

H3: The active game play will result in higher Quality of Life-Alzheimer's Disease scores compared to the control group and baseline after 8 weeks.

Methods

Study design and setting

An eight-week pilot/trial was conducted with randomized, comparative design. Participants were randomly allocated to a gaming (exercise) group and a usual-care (control) group (see Figure 1). This trial was conducted at Huafeng

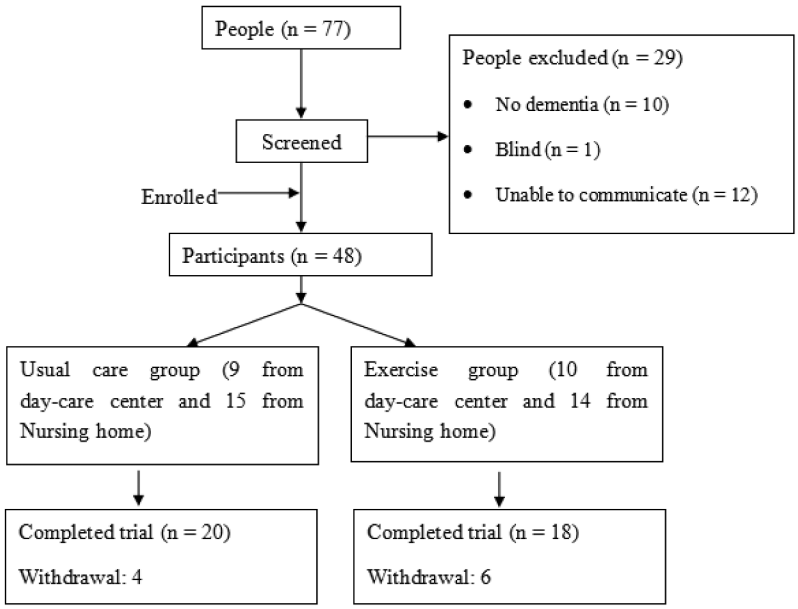

Figure 1. A flowchart showing the participants flow through the research process.

community, in Hangzhou city, P.R.China. The study site was selected for prior knowledge with the study population and rapport with the management team from a well-established, ongoing research collaboration (Zheng & Chen, 2017).

Ethics and consent

Ethics approval was acquired from the Hangzhou Normal University Ethics Committee (reference number: +86-0579-28,865,576). The study aim, plan, methods and communication of results were presented to and approved by the management of the participating organization.

Written informed consent was obtained from the participants and/or their primary caregivers prior to their inclusion in the study. For those participants who had lost the capacity to provide written consent, the process model of consent was applied (Dewing, 2007). This included identifying a representative, usually a relative or primary caregiver, for consent. Further information was gathered about the participant's possible means of signaling consent (e.g. personal behavior). The presence or absence of such signals was monitored during training to gauge the person's consent.

Sample size

The sample size was calculated based on the results of a previous study conducted in the same population with the same outcome measures reporting the average difference in a participant's Mini Mental State Examination (MMSE) score to be 2.75 with a standard deviation (SD) of 2.175 (Chen, 2013). We added 20% of allowance for dropouts (Tarraga et al., 2006; Zhuang et al., 2013). With the significance level (α) set at 0.05 and test power (1-β) at 0.80 (one-sided), the minimum sample size should be 31 people (Friedman, Furberg, & DeMets, 2010). Finally, we recruited 48 people allowing for attrition.

Participants

The criteria for inclusion were aged over 60 years, with medical diagnosis of dementia by a qualified specialist in geriatric medicine or psychiatry; having basic listening and comprehension ability; CSDD score below 8 (*Ru-Jing & Gang, 2008*) and giving written consent for participation in the study by themselves or their primary caregivers.

The criteria for exclusion were bedridden, severe hearing or visual impairment to impede basic communication, having acute delirium or confusion, terminal illness, or other disease known to affect the brain function or cognitive function, such as

Parkinson's disease or brain tumor, or were currently participating in another clinical trial or gaming.

Recruitment strategies

The Huafeng community runs a senior day care center and a nursing home, which was owned by the municipality government. Day care center offers care and supervision for older people during day time. As the study was conducted at these two sites in the same community, we sent fliers and advertised the study and recruitment process in press releases, as well as requesting referral by health care providers in the day care center. 19 people were recruited 9 consented via proxy. The study participants in the nursing home were referred by the nursing manager. With the approval of the management, the researcher sought further consent from the family member and the older people. Only after written consent was provided by the family member and oral consent was given by the older person, did the project proceed further, with 29 people recruited from the nursing home, 7 of them consenting via proxy.

We interviewed each participant using the MMSE and health history form under the companion of the family caregiver. If the person's MMSE score was below 26, and had a medical diagnosis of dementia from a medical doctor, the person would be considered as study participant. However, only after further screening using the inclusion and exclusion criteria, would the person be formally recruited into the pilot trial.

Method of randomization

Each eligible person was randomly assigned to either exercise or the control group according to a random number list. The list was generated with SPSS 19.0 by a statistician who was not directly involved in the study.

Blinding

After completing the baseline data collection, each old person was randomized into the exercise group or the control group. To avoid allocation bias, the research staff conducting the outcome assessment was blind to the allocation of the participant group. All participants were informed that they would have the opportunity to play the game; the control group could play the game after the intervention was completed.

Intervention

The length of intervention in the previous studies ranged from 1 day to 10 weeks, the duration of gaming varied from 5 min to an hour (Zheng, Chen, & Yu, 2017). The optimal efficacy was 8 week intervention period. Therefore, we designed the gaming to be offered 1 h/day, 5 days/week for 8 weeks. The box Kinect system was selected for the active game as it was considered feasible for use by this population. The game system consists of a Kinect sensor and a console. The console controls the game. First, a participant was asked to sit in a chair that was located 1 to 1.5 m away from the Kinect sensor. The position of the sensor was adjusted to ensure optimal capture of the person's position and motion by the infrared camera in the sensor (Park, Lee, Lee, & Lee, 2017). The training was provided by a nursing researcher in a group of five to six participants. After the initial training, the participants started to play. Each participant played the game for 10 minutes each time.

The Kinect game Fruit Ninja was selected as the exercise intervention to train the person's hand-eye coordination and motor skills. In the game, a player was faced with a variety of fruits flying in all directions on the screen. The task for the player was to use their upper arm as an imaginary sword to cut the fruits before they dropped to the bottom of the screen. This required the player to focus attention on the fruits amidst distractors, and act rapidly upon viewing the targets. Points were awarded for each successful cut. Bonus points were given if several fruits were cut with one slashing motion. To standardize the length of play, the game was set to last 1 min before a bomb was exploded. A pomegranate would appear at the end of each game. The player could slash it multiple times to win bonus points. If the sword touched the bomb, the player would be penalized 10 points.

In each session of the game, a researcher accompanied a participant to record the person's score and playing time. Motivational suggestions were

given, such as paying attention to the score of the last game, trying to beat it and to achieve a personal best. The participants also talked and joked with each other, sharing experiences of playing and achievements in scores, and competing with each other in a joyful environment. Upon the appearance of any sign of fatigue, or any abnormalities in breathing, the game play was immediately stopped. To prevent a fall in the process of play, a participant could choose to take the standing position or sitting in chair.

The study did not interfere with the participants existing pharmacological treatment or nursing care. The participants in both groups received their usual care.

Outcome measures

The assessment scores on cognition, quality of life, and depression for a participant were measured before and after 8 weeks of intervention. All measurements were performed by one third-year university nursing student who received training on these tasks.

Cognition was measured by Mini Mental State Examination (MMSE). MMSE (Folstein, Folstein, & McHugh, 1975) is the most widely used clinical assessment of cognitive function. The Chinese version has been translated, modified and validated by Katzman and colleges (1988), and it has been tested in a Chinese population (Li, Jia, Yang, & Moreau, 2016; Yu et al., 1989) and found to have excellent reliability and validity (test re-test was 0.91, α was 0.99) (Katzman et al., 1988). The Chinese version of the MMSE consists of 30 questions in six domains, including orientation, registration (repeating named prompts), attention and calculation, recall, language skills, and visuospatial construction. MMSE is scored from 0 to 30. The higher score indicates better cognition. The test for the MMSE indicated a good overall alpha (0.73).

Quality of life was measured by the Quality of Life-Alzheimer's Disease (QoL-AD) (Legouverneur, Pino, Boulay, & Rigaud, 2011). QoL-AD has 13 items covering the domains of physical health, energy, mood, living situation, memory, family, marriage, friends, self as a whole, ability to do chores around the house, ability to do things for fun, money, and life as a whole. QoL-AD is scored from 13 to 52; the higher score indicates better QoL.

Depression was measured by the Cornell Scale for Depression in Dementia (CSDD) (Chen, 2013). CSDD is designed for assessment of depressive symptoms in older people with dementia. It consists of questions on mood-related signs, behavioral disturbance, physical signs, cyclic functions, and ideational disturbance. Items are rated from 0 (absent) to 2 (severe) or symptom not possible to evaluate. A higher overall score indicates severe symptoms. The reliability of the Chinese version of CSDD was validated with Cronbach's alpha being 0.81 (Ru-Jing & Gang, 2008).

Data analysis

The data included in the analysis were collected from the participants who completed both pre- and post-intervention measurements. All statistical analyses were performed in SPSS19.0. As the data for age, MMSE, QoL-AD, and CSDD were continuous data, a t-test was used for within-group analysis and between-group analysis if the data was normally distributed. Otherwise a Mann–Whitney u-test was conducted. If the baseline data were categorical data, i.e., male and female, χ^2 test was used for comparison. Difference was considered as significant if $p < .05$. The sizes of within-group differences and between-group differences were measured by calculating effect size (Cohen's d) and the following intervals were applied for interpretations: 0.2–0.5 representing a small effect size; 0.5–0.8 representing a medium effect size; and 0.8 and higher representing a large effect size (Cohen, 1988; Morris & Deshon, 2002).

Results

Participant flow

Eighteen out of 24 participants in the exercise group completed the study. Six people dropped out; three suffered from poor physical health, one had no time to continue, and two did not give a reason. The daily attendance rate of the 18 participants in the exercise group was 100%. Twenty

Table 1. Baseline characteristics of the participants.

Characteristics		Exercise group	Usual care group	t value/ χ^2 value	P value
Age (years)					
Mean (SD)		81.74 (5.79)	84.26 (5.48)	1.398	0.171
Gender, n (%)	Male	3 (16.7)	6 (30.0)	0.932	0.334
	Female	15 (83.3)	14 (70.0)		
Education, n (%)	None	10 (55.6)	11 (55.0)	0.702	0.873
	Primary	6 (33.3)	5 (25.0)		
	Secondary	1 (5.6)	2 (10.0)		
	Higher Education	1 (5.6)	2 (10.0)		
Use of anti-dementia med, n (%)	None	4 (68.4)	6 (78.9)	1.254	0.534
Participation in social activities, n (%)	None	8 (42.1)	11 (57.9)	0.947	0.33
MMSE, mean (SD)		14.06 (6.66)	13.95 (7.37)	−0.046	0.963
QoL-AD, mean (SD)		28.17 (5.21)	28.00 (5.53)	−0.095	0.925
CSDD, mean (SD)		15.67 (5.88)	15.75 (9.36)	0.032	0.974

participants in the usual care group completed the study; four dropped out without explanation. There were no study-related adverse events reported by the participants, nor observed by the research team. There were no significant between-group differences in demographic variables and the MMSE, QoL-AD, and CSDD scores at the baseline (see Table 1).

Effectiveness of intervention on outcomes

Pre- and post-intervention comparisons of each group, between groups comparisons are shown in Table 2. After the intervention no significant between-group differences were found for the overall MMSE score (P = .252). The MMSE score of the exercise group showed a positive trend of improvement after the intervention, while did not reach statistically significant (P = .247). Therefore, hypothesis H1 was not supported. However, the exercise group had significantly higher levels of quality of life (P = .023) and lower levels of depression (P = .000) after the intervention. There was no within-group difference in the control group. A statistically significant difference between groups was found on quality of life (P = .005) and lower levels of depression (P = .001) after intervention. Therefore, hypothesis H2 and H3 were supported.

Discussion

The effects of active game play on older people with dementia was evaluated in this study. After receiving eight-week gaming, no significant change in overall cognition was found. This was different from a previous meta-analysis finding that video gaming can improve several dimensions of cognition in healthy older people, i.e., improving reaction time, attention and memory (Toril, Reales, & Ballesteros, 2014). This might be because the eight-week training period was not long enough, or the intensity level of exercise was not high enough. Another explanation may be that the MMSE measurement may not be sensitive enough in detecting changes in cognition in a short eight week period, although it has been widely used to effectively test the intervention effect on cognition for detecting dementia (Creavin et al., 2016). Cheung et al. (2019) administered a Cognitive Stimulating Play intervention on people with dementia for 8 weeks. Their intervention included batting a balloon, making handicrafts and card games. The intervention improved cognition as measured by Montreal Cognitive Assessment. In contrast to Cheung et al. (2019), we only provided one type of game; therefore, the outcome may not be as effective.

Significant improvement in quality of life and depression were achieved in the exercise group. Therefore, the positive effects of active game play on quality of life and depression in older people with dementia was validated in this study. This contributes much needed knowledge to support the potential inclusion of active game play into the non-pharmacological rehabilitation treatment for people with dementia.

QoL-AD measurement has been reported to be very useful for assessing quality of life for older people with dementia (Li et al., 2016). In the training group, the QoL-AD score was significantly improved after the intervention, and in comparison with the control group. This may be attributed to the active game play incorporating both socially and cognitively pleasant, competitive activities with physical activities. These can increase social interaction and improve mood for older people with dementia (Chiang, Tsai, & Chen, 2012), as seen in a significant improvement in the mood

Table 2. Pre- and post-intervention comparisons and between group comparisons in dependent variables.

		Exercise group		Usual care group				
Variables		M	SD	M	SD	Between groups (t value or Z value)	P value	Cohen's d
MMSE	Pre-intervention	14.06	6.66	13.95	7.37	−0.046	0.963	0.015
	Post-intervention	16.78	7.18	13.9	7.96	1.165	0.252	0.38
	Within group (t)	−1.179		0.021				
	P	0.247		0.984				
	Cohen's d	0.392		0				
QoL-AD	Pre-intervention	28.17	5.21	28	5.53	−0.095	0.925	0.03
	Post-intervention	31.83	3.99	27.25	5.5	−2.913	0.005**	0.96
	Within group (t)	−2.372		0.43				
	P	0.023		0.669				
	Cohen's d	0.788		0.145				
CSDD	Pre-intervention	15.67	5.88	15.75	9.36	−0.032	0.974	0
	Post-intervention	7.61	4.55	17.6	10.55	−3.856	0.001**	1.229
	Within group (t)	4.595		0.578				
	P	0.000**		0.561				
	Cohen's d	1.29		0.19				

score. Similarly, Yoon et al. (2013) found that an intervention combining cognitive training with active physical exercise can improve QoL of older people with dementia. Cahill and Diaz-Ponce (2011) suggest that social contact and pleasurable activity have significant positive impacts on patients' QoL as the game creates a distraction from the mind on illness, thus can block the deterioration of QoL in older people with dementia (Castro-Monteiro et al., 2016). Furthermore, the process of participating in the game provided the older people with a sense of self-achievement. These may have all accounted to the significant improvement in overall QoL-AD score, and in particular the scores for mood and friends after the eight-week gaming, as well as in comparison with the usual care group.

Depression is common among older people with dementia. It is associated with rapid cognitive and functional decline and increased caregiver burden. To date there is a lack of attention and strategy to manage this unavoidable symptom of dementia. Swinnen et al. (2021) found that an exergaming program can reduce depression of people with major neurocognitive disorder. Loneliness and lack of social support are associated with depression (Hermida, McDonald, Steenland, & Levey, 2012; Santini et al., 2016). Situating in a group setting undoubtedly increased social interaction for the participants who were in the gaming. Motivational feedback such as the encouraging remarks made by the group members and the supporting researcher could make the participants feel respected, boost self-esteem, and gain a sense of identity. The real-time, visual, and audio emotional support and performance feedback from the game were also fun and appealing, evoking a sense of meaning and self-actualization. There is no doubt that the game was effective in relieving depression for these older people with dementia.

Limitations

Four limitations are identified for this study. The first is the convenience sampling and confined sample size that may reduce generalizability. Due to a lack of rigorous prior research for this study to refer to, the sample size calculation was based on a small study conducted with similar participants but with different MMSE score. This may lead to the sample size calculation being less accurate. Second, most of the participants were receiving drug treatment and it was not appropriate to ask them to quit since the study was performed in a naturalistic setting; therefore, the finding could be compounded by dementia-related medications. As the participants were accompanied by a researcher in the entire process gaming process, the effect of the amenable social interactions with a young, friendly female nurse cannot be ignored in explaining the findings. Third, the study was limited to one community in Hangzhou which may limit generalizability to other groups and as the gaming was situated in a group setting, it is also possible that the improvements in quality of life and depression in acquired in our study was attributed to social interaction. Fourth, further follow-up assessment, outcome assessment after a longer period, i.e., half or one-year intervention, may increase

the rigor of the findings. Further comparative study between gaming and other group intervention are needed to investigate the impact of the social factor.

Clinical implications

The eight-week group active game play led to improvements in quality of life and reduction in depression for the older people with dementia. This supports its potential inclusion into the non-pharmacological interventions for older people with dementia.

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