

Research of Arithmetic and Drawing Writing in Improving Communication and Cognitive Function in Patients with Mild-to-Moderate Dementia: A Cluster Randomized Controlled Trial

ABSTRACT

Objective: The aim of the study was to investigate the effectiveness of arithmetic and drawing writing on communication skills, quality of life, and cognitive impairment among people with mild and moderate dementia.

Methods: We recruited 45 patients diagnosed with mild-to-moderate dementia into this study. The participants were randomly divided into arithmetic group (n = 14), drawing writing group (n = 16), and control group (n = 15). The arithmetic group was educated to understand the addition and subtraction formulas, then wrote down the correct answers between the number of 20 and 100. The drawing writing group was guided to name, draw, and write a given object. Both were trained by therapist for 12 weeks (40 minutes per week). Blinded assessors measured global cognitive function, communication skills, and quality of life using Mini-Mental State Examination (MMSE) scale, the subscales of Functional Assessment of Communication Skills scale and Quality of Life—Alzheimer's Disease scale at baseline and after 12 weeks' intervention.

Results: After the 12-week intervention, the participants with mild-to-moderate dementia of the arithmetic writing group and the drawing writing group showed statistically significant improvement in communication skills and quality of life compared with the control group (social communication: 6.00 ± 0.69 vs. 6.06 ± 0.92 vs. 3.98 ± 1.33 ; basic needs communication: 6.32 ± 0.48 vs. 6.42 ± 0.53 vs. 4.25 ± 1.49 ; quality of life: 33.23 ± 5.34 vs. 34.07 ± 3.49 vs. 25.07 ± 2.60). In addition, MMSE scores of the arithmetic group tended to improve after the 12-week intervention (14.77 ± 3.06 vs. 17.31 ± 4.80 , $P < .01$), but stabled in drawing writing group (14.27 ± 4.28 vs. 14.53 ± 5.26 , $P > .05$) and significant decreased in the control group (13.73 ± 2.58 vs. 10.13 ± 3.23 , $P < .01$).

Conclusion: Arithmetic, drawing, and writing are effective in improving communication skills and quality of life; arithmetic also could delay the decline of cognitive function in people with mild-to-moderate dementia.

Keywords: Dementia, communication ability, cognitive function, quality of life, non-pharmacological treatment

Introduction

Dementia, the chronic organic disease with progressive mental decline, is one of the greatest global challenges for healthcare and social services.¹ Globally, about 47 million people were living with dementia in 2015, and this number is projected to triple by 2050.² The decline in language communication ability and cognitive function among dementia patients increases the burden on their caregivers. However, effective intervention methods are limited, especially for improving the communication ability in patients with dementia.

Research on nonpharmacological treatment of communication skills in patients with Alzheimer's disease includes direct and indirect interventions. Direct interventions include

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cognitive training, such as spatial retrieval training^{3,4}; cognitive stimulation, such as recall therapy^{5,6}; cognitive rehabilitation, such as the application of cue cards⁷; and other methods, for instance, painting therapy⁸ and music therapy.⁹ Indirect interventions include training in communication skills and conducting communication activities.¹⁰⁻¹² Learning more healthcare conversation strategies enables interventionists to communicate effectively with people with dementia.

Arithmetic is an important part of cognitive training. Japanese scholar Kawashima and colleagues used addition arithmetic to improve cognitive function in patients with Alzheimer's disease.¹³⁻¹⁵ Additionally, the domestic Six-six Brain Company developed a game format based on the computer platform, such as playing cards, mah-jong, numerical ordering, numerical comparison, and calculation, for patients with dementia to enhance their cognitive abilities. The effectiveness of arithmetic in improving the communication ability among Alzheimer's disease patients is not clear. Furthermore, a proper arithmetic training mode is needed.

Painting therapy, regarded as a branch of art therapy, was advised to enhance the quality of life among patients with cancer, traumatic stress disorder, depression, and anxiety.^{11,12,16,17} By participating in art therapy, patients could express their feelings and relieve negative emotions.¹⁸⁻²⁰ Empirical randomized controlled trials have suggested that painting therapy improves the emotional apathy, quality of life, and cognitive function of patients with Alzheimer's disease.²¹⁻²³ However, these studies had limitations because the studies by Lee W J, Hattori H, and Mimica N from 2011 to 2016 had not evaluated the impact of painting therapy in enhancing language expression and social communication.

Communication barriers and cognitive impairment were significant factors leading to the decline of autonomy, feeling of self-identity, and perceived happiness among dementia patients.²⁴ Effective interventions targeting this topic are urgently needed. Thus, we conducted a 12-week study to understand the effectiveness of arithmetic and drawing writing, and to investigate their impacts on communication skills, quality of life, and cognitive impairment among mild and moderate dementia patients.

Material and Methods

Study Design and Participants

The study was conducted in a nursing home in Guangzhou, China, from March 2017 to June 2017. All participants signed a written informed consent form before participation in the study. The inclusion criteria were as follows: (1) adults aged ≥ 65 years

old; (2) diagnosed with dementia according to the International Classification of Disease, Tenth Revision (ICD-10); and (3) mild-to-moderate dementia, with Mini-Mental State Examination (MMSE) scores ranging from 10 to 27. The exclusion criteria were: (1) severe dementia (MMSE ≤ 9); (2) complications with severe somatic diseases that disabled their daily activities; and (3) serious visual and hearing impairment.

Sample Size

This study calculated the sample size based on the results of preliminary experimental data. Using inclusion and exclusion criteria, 15 elderly dementia patients were selected and randomly divided into 3 groups, with 5 members in each group. Each group would receive 4 weeks of arithmetic writing intervention, painting writing intervention, or only routine care. By investigating the mean scores (MMSE1=17, MMSE2=15.4, MMSE3=11.5) and overall standard deviation (SD=3.6) of the MMSE groups after intervention with $\alpha = 0.05$, $\beta = 0.10$, Gpower3.1.9.2 software was used to calculate the sample size. The minimum sample size obtained through software calculation was 36 cases. Considering the issue of sample loss, it was proposed to increase the sample size by 10%-20% based on this result, and approximately 40-43 cases needed to be included. Initially, a total of 52 eligible individuals were included. However, five out of 52 participants were excluded due to refusal to continue, and 2 participants dropped out because of referral to another nursing home. Eventually, 45 participants were analyzed in this trial.

Procedures

Informed consent was obtained from participants and their next of kin. To reduce contamination, participants were divided into 3 groups by floor unit of the building. Group 1 (n=15), group 2 (n=14), and group 3 (n=16) were administrated on the second, third, and first floor of the building, respectively. Randomized sampling (lottery) was used to allocate the intervention. After randomization, group 1 was assigned as control group, while group 2 and group 3 were assigned to conduct arithmetic writing and drawing writing, respectively. Participants in each group were evaluated at baseline and after intervention.

Trained therapists, who were unaware of group allocation, were assigned to implement arithmetic and drawing interventions following the instructions from blinded envelopes. Research assistants recorded the participants' emotional reactions and communication performance during the intervention. The contents of arithmetic and drawing followed the principle of gradual progression, with tasks conducted from simple to complex. Experimental groups (group 2 and group 3) received a 12-week training program, which was conducted as a 40-minute training session 3 times a week (36 sessions in total). Therapists and research assistants were not involved in the study outcome assessment.

Intervention

Arithmetic Group: Intervention was conducted individually, following these steps:

Step 1: Therapists introduced participants to the contents of the upcoming section and conducted orientation exercises regarding time and location.

MAIN POINTS

- At baseline, no significant differences were found between the 2 experimental groups and the control group in socio-demographic characteristics and outcome measures.
- After the 12-week arithmetic writing and drawing writing intervention, social communication, basic needs communication, MMSE, and QoL-AD scores of two experimental groups were significantly improved compared with the control group. In addition, MMSE scores of the arithmetic group tended to improve after the 12-week intervention, but stabled in the drawing writing group ($P > .05$) and a significantly decreased in the control group.

Step 2: Before the calculation task, participants were educated to understand the formulas of addition and subtraction, and then wrote the formulas on the whiteboard. The results of the calculation task were set between the numbers 20 and 100. During the calculation task, therapists would remind participants to correct any wrong calculation results or formulas immediately, and then continue to the next arithmetic question.

Step 3: After completing the calculation task, therapists would help participants summarize the results and provide positive feedback, then prepare for the next calculation task.

Drawing and Writing Group: Intervention was performed in a group by a therapist and an assistant in a multimedia room.

Step 1: Introduction. The therapist introduced participants with general content and then performed exercises in time and location orientation.

Step 2: Naming. Participants were guided to name objects out of the same species, such as different fruits or vegetables.

Step 3: Identification. Participants were guided to describe the classification, size, color, hardness, taste, cooking method, growing season, and other characteristics of the object with their own language.

Step 4: Drawing and writing. Objects were painted by the therapist first and described on the item in the screen. Meanwhile, participants copied the painting and words on the whiteboard.

Step 5: Summary. At the end of the training session, therapists would appraise the training results and emphasize their positive impact. Afterwards, participants would be led to recall all the objects and read the relative descriptions. Finally, therapists would schedule the next training session.

Control Group: Participants in the control group received routine nursing care, which included basic daily care, providing entertainment, and preventive education on falls.

Ethical Consideration

Ethical approval was obtained from the Guangzhou Medical University Human Research Ethics Committee (IRB No: 17022201). This trial used the CONSORT reporting guidelines²⁵ and was registered with the Chinese Clinical Trial Registry (Trial Registration Number: ChiCTR-IOR-17010827). The date of registration was March 9, 2017. Informed consent was obtained from all participants and their next of kin.

Outcome Variables and Tools

Firstly, the MMSE was adopted to evaluate the level of cognitive impairment. The MMSE was comprised of 6 domains, with the score range varying from 0 to 30. Higher MMSE scores indicated better cognitive function. The Chinese-version MMSE had a Cronbach's α of 0.91.²⁶

Secondly, communication skills were assessed using the Subscales of the Functional Assessment of Communication Skills (SFACS) developed by Frattali in 1995.²⁶ This 21-item, X-point Likert rating scale included 2 dimensions: social communication and basic needs communication. Higher scores indicated better communication function. The Chinese-version SFACS demonstrated acceptable internal consistency (Cronbach's α =0.93) and reliability (r =0.84).²⁷

Thirdly, the Quality of Life—Alzheimer's Disease (QoL-AD) scale developed by Logsdon was applied. This questionnaire included 13 items including physical health, energy, mood, living situation, memory, family, marriage, friends, self as a whole, ability to do chores, ability to do things for fun, money, and life. The questions were scored from 1 to 4 according to the Likert scale, with "poor" scoring 1 point and "excellent" scoring 4 points. The total score ranged from 13 to 52. High QoL-AD suggested greater perceived quality of life. The Chinese-version QoL-AD Cronbach's α was 0.88.²⁸

Statistical Analyses

Statistical analyses were conducted by Statistical Package for the Social Sciences (SPSS®) statistical software version 21.0 (IBM SPSS Corp.; Armonk, NY, USA). Socio-demographic variables and the scores of scales were characterized with descriptive statistics. One-way ANOVAs were performed to determine the differences of socio-demographic characteristics among arithmetic writing group, drawing writing group, and control group. At baseline and after the intervention, one-way ANOVAs were applied to identify the group difference in relation to MMSE, SFACS, and QoL-AD. To determine the effectiveness of arithmetic and drawing writing intervention, we analyzed the pre- and post-changes among groups. To compare the mean differences of MMSE, SFACS, and QoL-AD scores, independent paired t -tests were performed. Statistical difference was considered if the alpha level was below 0.05 (two-tailed).

Results

General Information

A total of 45 participants (20 male and 25 female) were included in the study, with an average age of 79.24 ± 6.90 years. The mean MMSE score was 14.13 (SD=3.31), indicating mild-to-moderate dementia. At the baseline, the mean score of FACS subscale and social communication was 4.21 (SD=1.21), and basic needs communication was 4.86 (SD=1.27). The mean score of QoL-AD was 26.84 (SD=3.87).

Baseline Comparison of Each Group

A baseline comparison of socio-demographic characteristics among the 3 groups is presented in Table 1. The baseline results of the study outcome measures, including MMSE, Social Communication, Basic Needs Communication, and QoL-AD, are presented in Table 2. At baseline, no significant differences were found between the 2 experimental groups and the control group in socio-demographic characteristics and outcome measures (all $P > .05$).

Comparisons After the Intervention

After the 12-week arithmetic writing and drawing writing intervention, social communication, basic needs communication, MMSE, and QoL-AD scores of 2 experimental groups were significantly improved compared with the control group (all $P < .05$; Table 2). No significant effects were found on cognitive function, social communication, basic needs communication, and quality of life between the arithmetic writing group and the drawing writing group (Table 2). After the intervention, all outcome measures of the experimental groups showed improvement, while all outcome measures of the control group decreased (Figure 1).

The pre- and post-comparison between the arithmetic group and writing group showed (Table 3) that both groups made significant improvements in scores of social communication ability, Basic

Table 1. Socio-demographic Characteristics Between Two Experimental Groups and the Control Group

Items	Total	Arithmetic Writing Group (n = 14)	Drawing Writing Group (n = 16)	Control Group (n = 15)	F/ χ^2	P
Age, years (m, SD)	79.24 ± 6.90	79.00 ± 6.35	78.56 ± 7.73	80.20 ± 6.83	F = 0.223	.801
Gender (n, %)						
Male	20 (44.4%)	8 (17.8%)	4 (8.9%)	8 (17.8%)	$\chi^2 = 3.844$.146
Female	25 (55.6%)	6 (13.3%)	12 (26.7%)	7 (15.6%)		
Education level (n, %)						
Primary school	23 (51.1%)	4 (8.9%)	11 (24.4%)	8 (17.8%)	$\chi^2 = 2.444$.785
Secondary school	17 (37.8%)	8 (17.8%)	4 (8.9%)	5 (11.1%)		
College and above	5 (11.1%)	2 (4.4%)	1 (2.2%)	2 (4.4%)		
Marital status (n, %)						
Married	23 (48.3%)	9 (20.0%)	8 (17.8%)	6 (13.3%)	$\chi^2 = 4.097$.405
Widowed	13 (26.7%)	4 (8.9%)	3 (6.7%)	6 (13.3%)		
Single	9 (25.0%)	1 (2.2%)	5 (11.1%)	3 (6.7%)		
Number of chronic diseases (n, %)						
Zero	4 (8.9%)	1 (2.2%)	1 (2.2%)	2 (4.4%)	$\chi^2 = 4.048$.416
One	23 (51.1%)	10 (22.2%)	7 (15.6%)	6 (13.3%)		
≥Two	18 (40.0%)	3 (6.7%)	8 (17.8%)	7 (15.6%)		

Needs Communication, and QoL-AD (all $P < .01$). After the intervention, MMSE scores of the arithmetic group and drawing and writing group increased, but only the MMSE score of the arithmetic group witnessed a significant improvement ($P < .01$).

In addition, in the control group, the pre and post comparisons of scores of Social Communication, Basic Needs Communication, and QoL-AD did not demonstrate statistical differences (all $P > .05$). Meanwhile, a decline in MMSE score was found ($P < .01$).

Discussion

This study found that functional communication and cognitive function in the arithmetic group had been enhanced, and were significantly better than those in the control group. Besides, functional communication in the drawing writing group had been greatly

enhanced and had also surpassed those participants in the control group. Compared to the control group, the quality of life of both experimental groups was remarkably improved after intervention. Despite the improvements in cognitive function, social communication, basic needs communication, and quality of life being obviously improved, we surprisingly noticed that there was no significant difference between the arithmetic group and the drawing writing group after the 12-week intervention.

The impairment of communication function in dementia patients often leads to serious behavioral issues, for instance disturbing behavior and aggression, which might cause significant pressure and burden to the nursing staff.^{29,30} The lack of effective communication between caregivers and patients leads to a series of adverse consequences, for example, interpersonal conflicts, relationship deterioration, social isolation, feelings of depression, and increased work burden of healthcare providers.³¹ Therefore, developing effective

Table 2. Comparison of Three Groups Before and After Intervention

Variables	Group	Pre-intervention			Post-intervention				F	P
		(M ± SD)	F	P	(M ± SD)	LSD-t ₁	LSD-t ₂	LSD-t ₃		
MMSE	AG	14.64 ± 2.98	0.270	.764	17.31 ± 4.80	1.627	4.207*	2.677*	9.124	.001**
	DG	14.06 ± 4.22			14.53 ± 5.26					
	CG	13.73 ± 2.58			10.13 ± 3.23					
Social communication	AG	4.02 ± 0.89	0.409	.667	6.00 ± 0.69	-0.147	5.203*	5.551*	19.566	.001**
	DG	4.17 ± 1.53			6.06 ± 0.92					
	CG	4.43 ± 1.13			3.98 ± 1.33					
Basic needs communication	AG	4.38 ± 1.19	2.513	.093	6.32 ± 0.48	-0.273	5.634*	6.129*	23.472	.001**
	DG	4.78 ± 1.54			6.42 ± 0.53					
	CG	5.39 ± 0.83			4.25 ± 1.49					
Quality of life	AG	26.79 ± 3.83	0.620	.543	33.23 ± 5.34	-0.566	5.525*	6.321*	23.982	.001**
	DG	27.63 ± 3.83			34.07 ± 3.49					
	CG	26.07 ± 4.04			25.07 ± 2.60					

AG represents the arithmetic writing group, DG represents the drawing writing group, and CG represents the control group. LSD-t₁ represents the intra-group comparison of AG and DG, LSD-t₂ represents the intra-group comparison of AG and CG, and LSD-t₃ represents the intra-group comparison of DG and CG; MMSE, Mini-mental State Examination.

* $P < .05$.

** $P < .01$.

Table 3. Within-group Comparisons for Each Group Before and After Intervention

Variables		Arithmetic Writing Group (M ± SD)			Drawing Writing Group (M ± SD)			Control Group (M ± SD)		
		M ± SD	t	P	M ± SD	t	P	M ± SD	t	P
MMSE	Pre-intervention	14.77 ± 3.06	-3.562	.004**	14.27 ± 4.28	-0.312	0.759	13.73 ± 2.58	7.263	.001**
	Post-intervention	17.31 ± 4.80			14.53 ± 5.26			10.13 ± 3.23		
Social communication	Pre-intervention	4.05 ± 0.92	-7.803	.001**	4.11 ± 1.56	-4.957	0.001**	4.43 ± 1.13	1.287	.219
	Post-intervention	6.00 ± 0.69			6.06 ± 0.92			3.98 ± 1.33		
Basic needs communication	Pre-intervention	4.46 ± 1.19	-4.542	.001**	4.70 ± 1.55	-4.514	0.001**	5.39 ± 0.83	2.344	.034
	Post-intervention	6.32 ± 0.48			6.42 ± 0.53			4.25 ± 1.49		
Quality of life	Pre-intervention	26.77 ± 3.98	-5.154	.001**	27.73 ± 3.94	-5.860	0.001**	26.07 ± 4.04	0.981	.343

MMSE, Mini-mental State Examination.

P* < .05.*P* < .01.

interventions improving communication ability in patients with dementia is necessary.

The presented study claimed that functional communication and cognitive function in the arithmetic group had been enhanced and were significantly better than those in the control group. Dementia patients might undergo communication impairment, including progressive degeneration of expression, receptive language, and impaired verbal fluency, resulting in the ultimate loss of functional communication.³²⁻³⁴ Studies have shown that arithmetical impairment was an early symptom of dementia.³⁵⁻³⁷ Similarly, Deleche et al³⁵ found that computational performance in dementia patients was associated with the MMSE score and language, but not with memory. At the same time, computing writing was related to working memory that affected cognitive function. Thus, this training process involved speech loops, visual loops, and central execution systems, which were closely related to simple arithmetic and complex arithmetic.³⁸ Therefore, performing arithmetic tasks could improve working memory and cognitive function in patients with dementia. The findings of the current study was in accordance with the SAIDO Learning study by Kawashima in 2015 in Japan.¹³ To conclude, the improvement of cognitive function might contribute to

improved language ability and expression ability. This phenomenon could be explained by the principle of neural plasticity and the law of "Use it or lose it".

Functional communication in the drawing writing group had been greatly enhanced and had also surpassed that of the participants in the control group. The drawing writing group adopted group therapy, where participants were encouraged to share their thoughts on the objects; therefore, the expression and language skills had been stimulated and improved. Furthermore, guided interaction between group members might also boost their willingness to communicate.

Additionally, being regarded as a branch of art therapy, previous studies verified that drawing writing therapy could relieve the negative emotions of patients with dementia and mild cognitive impairment (MCI).^{21,33,39} However, experts have claimed that the effectiveness of drawing writing therapy in cognitive improvement among patients with moderate dementia requires further investigation.¹⁰ In our study, the MMSE score of the control group progressively declined, meanwhile the MMSE score of the drawing writing group rose slightly, revealing that drawing writing training might play a vital role in maintaining cognitive function among dementia patients; therefore, rational research is needed to explore in the future.

Compared to the control group, the quality of life of both experimental groups was remarkably improved after the intervention.

In dementia patients, cognitive deficits were one of the significant factors leading to dysfunction of language and communication.^{40,41} The impairment of language function and communication hindered patients from expressing their needs accurately, which might affect their perceived quality of life and bring a heavy burden on caregivers in return.^{42,43} Empirical studies showed that the quality of life was related to cognitive function and communication in dementia patients.^{8,44} Therefore, we assumed the improvement of quality of life might be associated with the promotion of cognitive function and communication ability.

Despite the improvement in cognitive function, social communication, basic needs communication, and quality of life being obviously improved, we surprisingly noticed that there was no significant difference between the arithmetic group and the drawing writing group after the 12-week intervention. Thus, it could be seen that both interventions were equally effective. Our results suggest that clinicians should recommend individualized training contents to

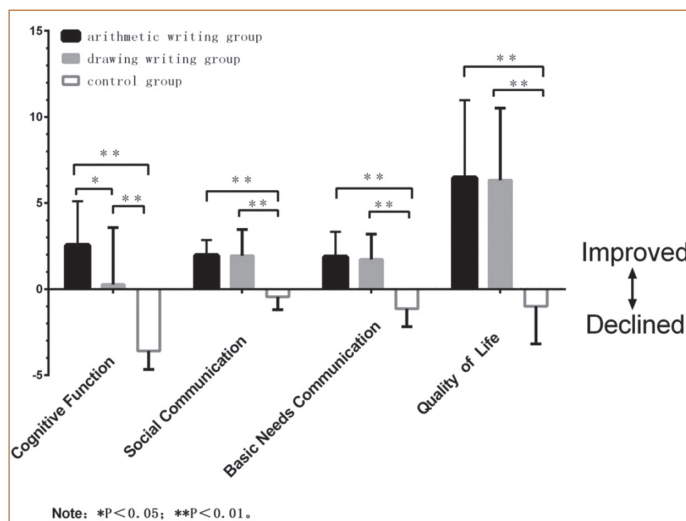


Figure 1. Comparison the Difference of D-value of Pre- and Post-intervention in the Two Experimental Groups and the Control Group. **P* < .05; *P* < .01.

patients based on their personal preferences and physical condition. This view of treatment selection in line with the concept of human-centered care developed by Kitwood, which states that the treatment plan should balance clinical efficacy, patient preferences, and treatment adherence.

This study had several limitations. First, the sampling size was small; thus, results should be interpreted cautiously. Second, although the outcomes were evaluated using rating scales with acceptable validity and reliability, further studies should apply objective indicators to address these limitations.

In general, non-pharmacological therapy plays an important role in the treatment of people with dementia. The study indicated that arithmetic, drawing, and writing were effective in improving communication skills and quality of life. Additionally, arithmetic could delay the decline of cognitive function in people with mild-to-moderate dementia.

Availability of Data and Materials: The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Ethics Committee Approval: Ethical approval was obtained from Guangzhou Medical University Human Research Ethics Committee (IRB No: 17022201). This trial was registered at the Chinese Clinical Trial Registry (Registration Number: ChiCTR-IOR-17010827).

Informed Consent: Informed consent was obtained from the participants and their next of kin who agreed to take part in the study.

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