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A Pilot Study to Explore the Improvements in Pulmonary and Cognitive Functions With a Kazoo Intervention Among Middle-Aged and Older Adults in a Rural Community

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Abstract

Dementia is a leading cause of disability and dependence in older adults worldwide. The aim of this pilot study was to explore the effect of using a kazoo instrument to improve pulmonary function and cognitive reserve in middle-aged and older adults in rural areas. This quasi-experimental study was conducted at two community care stations selected using cluster sampling from a rural district in southern Taiwan. We enrolled 85 middle-aged and older adults who were randomly assigned into self-learner and in-class groups. Both groups received a 6-month kazoo program. Cognitive and pulmonary function were compared before and after the intervention between the two groups. Significantly improved pulmonary function with regards to forced vital capacity ($p < .05$) was found in the self-learner group, and significantly improved maximum expiratory flow 75% ($p < .001$) was found in both groups. Mini-Mental State Examination scores significantly improved in the self-learner group ($p < .01$), but there was no significant change in the in-class group. Our results suggest that community care stations could consider implementing wind instrument programs such as a kazoo to enhance pulmonary function and cognitive reserve in middle-aged and older adults residing in rural areas.

Keywords

Alzheimer's/dementia, cognitive impairment, community, global public health, long-term care

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What this paper adds

- A 6-month kazoo program significantly improved pulmonary function in middle-aged and older adults residing in rural areas.
- The use of wind instruments to enhance cognitive reserve may have a significant impact on the quality of life in these groups.
- This pilot study found that using a self-learning method resulted in better health improvements than a usual in-class learning strategy.

Applications of study findings

- The kazoo is a small musical instrument that is convenient to carry. Health providers can use interventions with the kazoo to promote health demands in rural middle-aged and older adults.
- Health providers could also use interventions with the kazoo in different health institutes to help prevent dementia.
- An effective kazoo program can be based on a sustainable self-learning process or group learning with a more supportive environment.

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Introduction

Dementia causes a progressive and irreversible decline in mental and physical functions due to the loss of neurons and brain function (National Institute of Neurological Disorders and Stroke (NINDS), 2023). In addition, an association between cognitive impairment and a decline in pulmonary function has also been demonstrated in older people (Gallina et al., 2020). Delaying the onset of dementia by 5 years has been estimated to reduce the total number of cases by half globally, and consequently greatly reduce the burden of medical care (Gitlin et al., 2008; Khachaturian & Khachaturian, 2009).

Against the backdrop of a rapidly aging population and heavy impacts of dementia, particularly in low- and middle-income developing countries (World Health Organization, 2023), non-pharmacologic interventions are increasingly being used to control long-term illnesses and promote health and well-being (Leggieri et al., 2019; Loftus et al., 2017; Morse et al., 2022). Further, according to the Trends in Death Rates in Urban and Rural Areas: United States (U.S.), 1999 to 2019 report, the age-adjusted death rate in rural areas was 7% higher than that in urban areas (Curtin & Spencer, 2021). In addition, the Centers for Disease Control and Prevention (CDC) reported that the major risk factors for rural health disparities in the U.S. were geographic isolation, lower socioeconomic status, higher rates of health risk behaviors, limited access to healthcare specialists, and subspecialists (Rural Health Information Hub, 2023). Thus, it is essential to develop early prevention and effective strategies to assist rural populations meet their health demands, especially with regards to dementia.

Regarding the relationship between pulmonary function and cognitive function, Gallina et al. (2020) demonstrated an association between worsening pulmonary function with cognitive impairment, and that this may be a predictive risk factor for dementia in old age. In addition, Russ et al. (2020) conducted a systematic literature review of 10 articles on pulmonary function and the incidence of dementia in later life and 11 articles on the relative risk of respiratory diseases and dementia. The authors divided pulmonary function parameters into four groups for comparison, and found that the relative risk of dementia was 1.46 times higher in the highest forced vital capacity in the first second (FEV1) group compared with the lowest FEV1 groups. In addition, they found that respiratory diseases increased the odds of dementia by 1.54 times (Russ et al., 2020). In addition, Ferreira et al. (2015) reported that pulmonary function could be improved by walking and breathing exercises, but that after 6 months of follow-up, only the breathing training group showed significant improvements in cognitive function such as abstract thinking and cognitive flexibility.

Previous research has demonstrated that cognitive function may be improved through the application of non-pharmacologic interventions such as music therapy (Leggieri et al., 2019). Leggieri et al. (2019) conducted a systematic literature review on music therapy in patients with dementia and Alzheimer's disease, and found that individualized music therapy was the most effective, listening to music could achieve the purpose of relaxation, and actively engaging in music activities could increase social interactions and obtain immediate feedback. Their findings suggest that music interventions could be used in a variety of different forms for the purpose of improving behavior and cognition (Leggieri et al., 2019).

In further studies of music therapy, Gómez Gallego and Gómez García (2017) implemented a 6-week course of active music therapy (AMT) (90 min per week), and reported significant improvements in cognitive function. In addition, Giovagnoli et al. (2017) reported that a 12-week course of AMT (1 hr per week) resulted in better improvements in Word Fluency Task and Short Story Test than a neuroeducation program, but that there was no significant improvement compared with the control group. Even though the changes in cognitive function in the older adults and people living with Alzheimer's disease in their study may not have only been due to the music intervention, these findings may suggest that at least 90 min of AMT per week can provide a complementary method to enhance and maintain intelligence.

Music therapy and music medicine have been applied for many years. The mechanism of music therapy may be explained by the gate control theory (Melzack & Wall, 1965), first proposed by Melzack and Wall (1965). Music is transmitted to the reticular activating system and limbic system through a spinal cord reticular pathway, causing the pituitary gland to release endorphins and reduce the secretion of catecholamines. This then results in emotional relief, thereby reducing restlessness, anxiety and hostility, and reducing pain (Hayes et al., 2003). Music therapy is more operator-dependent than music medicine, and as such it relies on the passion and expertise of the therapist and may involve an intermittent schedule. On the other hand, music medicine is less interactive and involves the patients listening passively to prerecorded music (Bradt et al., 2013; Cole & LoBiondo-Wood, 2014; Dóro et al., 2017; Horuz et al., 2017).

Several studies have investigated whether the use of wind instruments in music therapy and music medicine can improve pulmonary function. Kim et al. (2018) and Rajaratnam et al. (2018) investigated the combination of a community breathing exercise course with playing wind instruments including the kazoo in a pilot study of patients with cerebral palsy. Their results showed that this intervention could effectively improve vital capacity, cardiorespiratory endurance and life satisfaction. In Taiwan, Liu and Kuo (2011) also reported that playing wind instruments requires sufficient pulmonary capacity, respiratory muscle strength, skilled breathing control, patency of the airway, and full coordination of the mouth and throat in order to play music. Further, they stated that when playing a musical instrument, the lips must maintain sufficient air pressure to maintain the intensity of the sound, and that air pressure has an important relationship with the respiratory muscles (Liu & Kuo, 2011).

Taken together, these findings suggest that playing a wind instrument and breathing training may enhance pulmonary function and consequently improve cognitive status. However, few studies have addressed the effect of a kazoo musical instrument intervention on improving pulmonary function and cognition in middle-aged and older adults residing in rural areas. Therefore, the research hypothesis was that sustainable learning and practicing the kazoo may improve pulmonary function and cognitive function among middle-aged and older adults residing in rural areas.

Methods

Design

The present study used a quasi-experimental design to investigate the effectiveness of the study intervention over a 6-month period from October 2021 to March 2022 in rural areas of southern Taiwan.

Participants

In Taiwan, the Long-Term Care Plan 2.0 was implementation with the goal of establishing a community whole-care model by transforming community care stations into community care bases. According to the Ministry of Health and Welfare in Taiwan, there were a total of 4,799 community care stations as of December 2022. These care stations provide continuous and localized care services including home visits, phone calls, consultations and transfer service, meal delivery and health promotion programs. The diverse health promotion programs include fitness, healthy diet, board games, dancing, gardening, arts and crafts, and social participation (being a volunteer).

Of the 10 community care stations providing long-term care services located in rural areas of southern Taiwan, two were selected using cluster sampling. The participants were randomly assigned into two intervention groups by flipping a coin, a self-learner group and an in-class group. The inclusion criteria were: (1) adults aged 50 years and above.; (2) Mini-Mental State Examination (MMSE) score of 19 to 21 (for those with no formal education) or 21 to 24 points (for those with formal education); and (3) ability to communicate in Mandarin or Taiwanese. The rationale for choosing 50 years of age as the cutoff was based on a study by Sabia et al. (2019), who reported that having poor cardiovascular health at 50 years of age was linked to a higher risk of dementia in later life. The exclusion criteria were: (1) moderate/severe dementia; (2) respiratory infection; (3) those who could not communicate in Mandarin or Taiwanese.

The sample size was estimated using G*power statistical software version 3.1.5 and based on repeated analysis of variance to achieve a power of 0.8, effect size of 0.5, and alpha level of 0.05. Since the withdrawal rate in rural areas is particularly high for middle-aged and older adults, we invited 101 rural residents to participate in this study from the beginning of the research period. However, the final valid sample was 85, with a completion rate of 84%.

Study Procedure

This study was approved by the Human Research Ethics Committee (REDACTED), and was conducted in accordance with the Declaration of Helsinki. Participants with any acute or chronic condition that limited their ability to participate in the study and those who refused to provide informed consent were excluded. All participants who met the eligibility criteria were informed about the study, and those interested in participating were enrolled after providing written consent. The study participants received incentives after an in-person survey which took around 30 min to complete.

Data Collection

Each study participant underwent tests to measure pulmonary function and estimate cognitive function in the community care stations at the beginning of the study and within 1 week of the end of the intervention. All of the participants followed the researchers' instructions on how to use a spirometer (Spirobank II, MIR), and they were asked to blow three times for each estimate. The pulmonary function parameters were: FEV1, forced vital capacity (FVC), FEV1/FVC%, maximum expiratory flow (MEF)25%, and MEF75%.

In addition, we conducted a face-to-face interview and applied the Chinese version of MMSE (Zhang et al., 1990). The Chinese version of the MMSE maintains consistency with the original version developed by Folstein et al. (1975), namely: time & place orientation, registration, attention & calculation, recall, language & constructional ability. The MMSE has a total score of 30 points (1 point for each sub-item), with a lower score indicating greater cognitive impairment. The MMSE has been shown to have good test-retest reliability (0.80–0.95) and acceptable sensitivity and specificity (Folstein et al., 2001; Kahle-Wrobleski et al., 2007).

Intervention—The Kazoo Program

The participants were given a music handbook which included self-report pages to record practice dates and duration and 10 popular song pages. Considering that local community care centers sometimes celebrate festivals and hold activities such as organizing a trip, the

Table 1. Characteristics of the Study Groups.

Variables	Self-learner group $N=41$	In-class group $N=44$	p value
Gender[a]			
Female	29(70.7)	34(77.3)	.491
Male	12(29.3)	10(22.7)	
Age (years)[b]	76.88 ± 9.47	76.34 ± 9.40	.794
BMI (kg/m^2) [b]	24.57 ± 5.00	25.06 ± 3.91	.614
Education[a]			
None& Self-study	9(21.9)	18(40.9)	1.36
Primary school	18(43.9)	13(29.5)	
Junior high school	5(12.2)	8(18.2)	
Senior high school and above	9(21.9)	5(11.4)	
Chronic Disease[a]			
Hypertension	19(46.3)	17(38.6)	.517
Diabetes	16(39.0)	4(9.1)	.001***
Hyperlipidemia	9(22.0)	2(4.5)	.017*
Asthma	3(7.3)	1(2.3)	.272
Heart Disease	3(7.3)	5(11.4)	.449
Rheumatoid Arthritis	3(7.3)	1(2.3)	.138
Cancer	0(0)	1(2.3)	.332
Renal Disease	0(0)	1(2.3)	.332
Psychiatric disorder	1(2.4)	1(2.3)	.960
Mental Cognitive Impairment	0(0)	1(2.3)	.332

Note. Categorical variables presented as *N*(%); continuous variables presented as Mean ± *SD*.
[a]Chi-square test.
[b]*t* test.
*$p \leq .05$. ***$p \leq .001$.

kazoo program was held three times per month over a 6-month period, for a total course time of 36 hr ([3 w × 6 m] × 2 hr =36 hr). The self-learner group practiced the kazoo independently. The participants were asked to present their practice recordings once a month at the community care stations during the research period.

The in-class kazoo course was designed in three phases: Phase 1, the introductory stage; Phase 2, the advanced stage; and Phase 3, the proficient stage. In Phase 1 (introduction), the participants were taught how to play the kazoo to ensure that they could use it correctly. The participants were then taught how to practice a familiar Taiwanese folk song, such as "Watching the Spring Breeze," so that they could better control the rhythm and pitch of the music. In Phase 2 (advanced stage), the participants were taught to practice different playing skills and to change between fast and slow songs to make it more fun and challenging. In Phase 3 (proficient stage), the participants practiced their favorite songs during community festivals, and shared their learning experiences with others.

Statistical Analysis

Due to reasons including illness, physical discomfort, and loss of follow-up, some data of the participants were missing. To handle missing values, we applied the multiple imputation method to reduce bias of the results. Participants who withdrew from the study, were lost to follow-up or died were excluded. All data in this study were analyzed using SPSS version 26 (IBM Inc., Armonk, NY), and the t-test and chi-square were used. In addition, a GEE model and an AR(1) (first-order auto-regressive) tool correlation matrix were used to control for the effect of time; the factors included experimental group, time point, age, gender, education level, illness, and experimental group * time point, where the first two were the main effects and the last was the interaction effect.

Results

Population Characteristics

Eighty-five people were enrolled in this study, including 41 in the self-learner group [29 females (70.7%) and 12 males (29.3%)], and 44 in the in-class group [34 females (77.3%) and 10 males (22.7%)] (Table 1). We classified education into four levels: (1) no formal education or self-study, (2) primary school, (3) secondary school, and (4) senior high school and above. The in-class participants had a lower educational level, with 40.9% having no education or self-study compared to the self-learner group (21.9%). Most of the self-learner group had an educational level of primary school (43.9%) and senior high school or above (21.9%). However, there was no significant difference between the two groups in educational level.

Table 2. Comparisons of FVC, MEF75% and MEF25% Before and After the Intervention.

		Before	After	
Variables	*N*	Mean ± *SD*	Mean ± *SD*	*p* value
FVC (L)				
Self-learner group	41	1.66 ± 0.43	1.84 ± 0.61	0.041*
In-class group	44	1.42 ± 0.47	1.58 ± 0.43	0.068
MEF75% (L)				
Self-learner group	41	2.05 ± 1.37	2.47 ± 1.42	0.001***
In-class group	44	2.20 ± 1.71	2.29 ± 1.53	0.001***
MEF25% (L)				
Self-learner group	41	0.84 ± 0.31	0.90 ± 0.54	0.948
In-class group	44	0.80 ± 0.46	0.89 ± 0.65	0.205

*$p \le .05$. ***$p \le .001$.

Table 3. Comparisons of Cognitive Function Before and After the Intervention in the Self-Learner Group.

	Before	After	
Cognitive function *N* = 41	Mean ± *SD*	Mean ± *SD*	*p* value
M1 _Orientation	8.80 ± 1.66	9.23 ± 1.07	.047*
M2_ Attention	5.68 ± 2.26	6.41 ± 1.43	.056
M3_ Recall	2.02 ± 1.15	2.77 ± 0.49	.001***
M4_ Language	4.27 ± 0.95	4.59 ± 0.69	.025*
M5_ Praxis	2.71 ± 0.56	2.85 ± 0.48	.012*
M6_ Constructive abilities	0.71 ± 0.46	0.67 ± 0.38	.615
MMSE (total)	24.20 ± 5.43	26.61 ± 3.18	.002**

*$p \le .05$. **$p \le .01$. ***$p \le .001$ (using the *t* test).

The mean age of the participants was 76.88 ± 9.47 years in the self-learner group and 76.34 ± 9.40 years in the in-class group. The self-learner group had a mean body mass index of 24.57 ± 5.00 kg/m^2, compared to 25.06 ± 3.91 kg/m^2 in the in-class group. There was no significant differences in BMI between the two groups.

Regarding health issues, the participants were assessed for chronic diseases and risk factors such as head injuries and smoking. The self-learner group had significantly higher rates of diabetes and hyperlipidemia than the in-class group ($p < .001$ and $p < .05$, respectively). Table 1 shows the demographic characteristics of both groups.

Pulmonary Function

All participants received two pulmonary function tests before and after the intervention. Before the intervention, 47.1% of the in-class group had normal pulmonary function, compared to 31.8% of the self-learner group. However, after the intervention, the self-learner group had a greater increase (13.7%) than the in-class group (5.8%). Among the abnormal findings, most of the participants had a restrictive abnormal pattern.

In terms of obstructive abnormalities, four participants in the self-learner group and two participants in the in-class group had obstructive abnormalities before the intervention, but after the intervention only two cases in the self-learner group and one in the in-class group had obstructive abnormalities. These results showed that the intervention resulted in obvious improvements in those who had abnormal or partially abnormal pulmonary function.

Comparisons of FVC, MEF75% and MEF25%

FVC, MEF75% and MEF25% in the participants were compared before and after the intervention. FVC is the maximum amount of air that can be exhaled after one deep breath. The results showed that the self-learner group had significant increases in FVC ($p < .05$) and MEF75% ($p < .001$) after the intervention, and that the in-class group had a significant improvement in MEF75% ($p < .001$). However, there was no significant change in MEF25% in either group (Table 2).

Comparisons of Cognitive Function

The MMSE score improved from 24.20 ± 5.43 to 26.61 ± 3.18 in the self-learner group, and from 22.60 ± 2.6to 22.89 ± 2.87 in the in-class group. The results showed that there was a significant increase in MMSE score in the self-learner group ($p < .01$) (Tables 3 and 4). The self-learner group had significant improvements in cognitive

Table 4. Comparisons of Cognitive Function Before and After the Intervention in the In-Class Group.

	Before	After	
Cognitive function *N* = 44	Mean ± *SD*	Mean ± *SD*	*p* value
M1 _Orientation	8.73 ± 1.07	8.76 ± 0.90	.831
M2_ Attention	5.14 ± 1.41	5.141 ± 1.41	.998
M3_ Recall	2.04 ± 0.63	2.02 ± 0.88	.895
M4_ Language	3.28 ± 0.69	3.64 ± 0.67	.002**
M5_ Praxis	2.59 ± 0.50	2.64 ± 0.49	.420
M6_ Constructive abilities	0.56 ± 0.38	0.57 ± 0.36	.840
MMSE(total)	22.60 ± 2.60	22.89 ± 2.87	.465

$^{**}p \leq .01$. (using the *t* test).

Table 5. Comparisons of MMSE Estimates Between the Self-Learner and In-Class Groups by GEE Analysis.

Parameter estimates Variable	B (95% CI)	SE	Wald χ^2	*p* value
Intercept	24.40 [18.70, 30.10]	2.91	70.29	.001***
Group (*self-learner* vs. *in-class)*	0.13 [–1.29, 1.55]	0.73	0.03	.859
Time (Post vs. Pre-test)	0.30 [–0.44, 1.03]	0.38	0.61	.433
Group × time	2.12 [0.52, 3.71]	0.81	6.78	.009**

$^{**}p < .01$. $^{***}p < .001$.

function on orientation, recall, language and praxis domains ($p < .05$, $p < .001$, $p < .05$, and $p < .05$, respectively) (Table 3). On the other hand, the in-class group only had a significant improvement in the language domain ($p < .01$) (Table 4).

GEE analysis showed that after controlling for age, gender, education level and illnesses, there was a significantly higher change in MMSE score in the self-learner group than in the in-class group (B=24.40, Wald $\chi 2$=70.29, $p < .001$) (Table 5). There were significant differences in the change in MMSE score between the self-learner and in-class groups before and after the intervention.

Discussion

In this pilot study, we found that regularly practicing the kazoo over a 6-month period enhanced pulmonary function in middle-aged and older adults living in rural areas. This finding is consistent with the studies of Kim et al. (2018) and Rajaratnam et al. (2018) on people living with dementia, Alzheimer's disease and cerebral palsy. In addition, our kazoo intervention also improved cognitive function, which is consistent with the studies of Gómez Gallego and Gómez García (2017) and Giovagnoli et al. (2017). However, these previous studies were conducted over a short period of 6 or 12 weeks, compared to the longer duration of 6 months in our study. Both participants in the self-learning group and in-class group in the present study had a strong interest in learning the kazoo.

In addition, our results showed that self-learning had a greater impact on improving pulmonary function. This finding is different from previous studies by Leggieri et al. (2019), Gómez Gallego and Gómez García (2017) and Giovagnoli et al. (2017), who reported that at least 90 min of AMT per week may result in better outcomes. Our results showed a significant improvement in cognitive function in the self-learner group, but only language function improved in the in-class group. The self-learner group reported that they chose their favorite songs and practiced them frequently at home or outdoors. They also shared their learning experiences and performed their favorite songs for their family and friends. Therefore, the frequency of practicing the kazoo may be an important factor affecting the cognitive level.

However, the in-class group had more opportunities to interact with other people and could chat freely during the class break time. In addition, whenever they had difficulty to play along with public songs, they would consult an instructor. These factors may have improved their language function.

Finally, our results suggested that education experience may influence the kazoo learning process. We provided a self-designed kazoo learning handbook to remind the participants to practice and record practice dates and duration. However, some participants had obstacles to using the handbook due to a lower education level. In addition, if the participants wanted to listen to a favorite song when they practiced the kazoo, they had to use a smart phone, computer or other device. In rural areas of southern Taiwan, some older adults have limited access to such technology, and rather usually watch television or listen to the radio. Thus, in the future, health providers at rural community care stations should consider providing a more supportive environment, such as broadcasting a kazoo video curriculum on television or encouraging middle-aged and older adults to practice frequently along with karaoke during their leisure time, as karaoke is a very popular activity in Taiwan.

Limitations

Some limitations of this study should be considered. First, there was a significant difference in chronic illness status at baseline between the two groups, which may have been due to the small sample size. Second, this study applied a quasi-experimental design without recruiting a control group, and thus there may have been bias as the adults who considered joining this study may have enjoyed musical activities or learning musical instruments. Third, during the COVID-19 pandemic, some of the participants withdrew from this study due to refusing face-to-face interviews or receiving pulmonary function tests without wearing a mask. This may have affected the generalizability of the study findings. Fourth, it could be argued that many kinds of exercise may improve pulmonary function, not only the kazoo. These results therefore need to be interpreted with caution. However, our study participants embraced practicing the kazoo into their lives, and they achieved an improvement in pulmonary function.

Conclusion

Our novel findings may serve as new evidence for future research and prompt further studies. Our findings demonstrated the feasibility and utility of implementing a wind instrument device intervention to improve pulmonary function and cognitive function. However, a longitudinal study is still needed to observe the long-term effects of a kazoo intervention on the early prevention of cognitive impairment.

This pilot study suggests that community health care providers may consider implementing programs with musical devices such as the kazoo to improve cognitive reserve for middle-aged and older adults living in rural areas.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical Approval

The study was approved by the ethics review board of National Cheng Kung University Human Research Ethics Committee. The Approval No. NCKU HREC-E-110-059-2.

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