Journal of Medical - Clinical Research & Reviews

# Effect of Tongue and Lip Motor Training for Cognitive Function in Older People: -The Relationship of Oral Function and Cognitive Function

# Minoru Innami<sup>1</sup>, Masayo Okumura<sup>2</sup>, Junichi Otogoto<sup>1</sup>, Eiji Kondo<sup>2</sup>, Norio Sogawa<sup>3</sup>, Masami Niwa<sup>4</sup>, Tadashi Ogasawara<sup>1</sup>, Mihoko Tomida<sup>1\*</sup>

<sup>1</sup>Department of Oral Health Promotion, Graduate School of Oral Medicine, Matsumoto Dental University, Nagano, Japan.

<sup>2</sup>Department of Oral Anatomy, Matsumoto Dental University, Nagano, Japan.

<sup>3</sup>Department of Molecular Engineering and Drug Developmental Sciences, Graduate School of Oral Medicine, Matsumoto Dental University, Nagano, Japan.

#### \*Correspondence:

Mihoko Tomida, D.D.S., Ph.D, Department of Oral Health Promotion, Matsumoto Dental University, 1780 Gobara Hirooka, Shiojiri-shi, Nagano 399-0781, Japan, Tel : +81-263-51-2208.

Received: 10 June 2021; Accepted: 17 July 2021

<sup>4</sup>Department of Radiological Technology, Gifu University of Medical Science, Gifu, Japan.

**Citation:** Innami M, Okumura M, Otogoto J, et al. Effect of Tongue and Lip Motor Training for Cognitive Function in Older People: -The Relationship of Oral Function and Cognitive Function. J Med - Clin Res & Rev. 2021; 5(7): 1-8.

# ABSTRACT

**Introduction:** The oral function with many teeth affects the health maintenance of the whole body and brain activation of the older people. This study investigates the relationship between cognitive and oral functions, and the effect of tongue and lip motor training on cognitive function.

**Methods:** One hundred subjects (age > 65) were investigated Mini-Mental State Examination (MMSE), their number of present teeth, masticatory function, occlusal force, and oral diadochokinesis (ODK), and correlations between their MMSE scores and the other factors were discussed. Fifteen subjects (5 non-impairment group: NIG, 10 impairment group: IG) participated in tongue and lip motor training three times daily for 15 months. Their MMSE scores, masticatory function, occlusal force, and ODK times were measured every three months.

**Results:** Their MMSE scores correlated with age, number of present teeth, masticatory function, and ODK. Furthermore, multiple regression analysis showed that MMSE scores were strongly related to age and ODK. MMSE scores of IG were significantly higher after 15 months of pronunciation than before training and three months after training started. In both groups, ODK times after 15 months of training were significantly higher than before the training and three months training started. Their masticatory function and occlusal force in the IG showed no significant differences during the 15 months of training.

**Conclusions:** The findings suggest that cognitive function may be related to oral function, especially pronunciation, and those 15 months of tongue and lip motor training is effective in improving cognitive and pronunciation functions.

#### **Keywords**

Mini-mental state examination, Oral diadochokinesis, Older people, Oral function.

# Introduction

The number of patients with dementia has surpassed six million in Japan, a country with a "super-aged" society. The number of

Recent studies have explored various non-pharmacological intervention programs and found that cognitive training such as learning therapy can improve cognitive function, which depends on the plasticity of the nervous system [2,3]. Some studies have found that enjoyable activities, reading, playing games, dancing, and music therapy, significantly reduced the risk of dementia [4] and cognitive impairment [5,6]. Moreover, these activities have a positive effect on both cognitive function and mental health, including depressive symptoms, among older people [7]. Consequently, home-based training sessions or hands-on activities have been introduced as effective measures against dementia. Music therapy has been found to improve cognitive function in early-stage dementia [8,9]. Task such as playing musical instruments can also significantly improve the frontal lobe function in patients [10]. However, to play games or musical instruments at home, people need to buy the device or instrument. Therefore, despite showing positive results, costly intervention programs are not widely used in clinical settings [11]. In sum, few studies have investigated the long-term effects of training or activities on patients with dementia. Therefore, it is necessary to develop individual interventions that are low cost and include personalized training programs and enjoyable content.

Regarding oral functions, numerous prospective studies have reported on an association between oral health and dementia in old age [12]. Particularly, tooth loss was independently associated with the development of cognitive impairment and poor nutrition [13]. Recent research has also demonstrated that the dexterity of the tongue simultaneously improved pronunciation functions [14]. Body strength, which is related to tongue pressure is very important for preventing sarcopenia dysphagia (i.e., swallowing disorders) in the elderly [15]. As strengthening the tongue has been found to be important for maintaining and improving the health of old people, we hypothesized that tongue and lip motor training may improve tongue pressure and dexterity. Therefore, this study aims to investigate the relationship between the cognitive function and oral function, and to clarify the effects of tongue and lip motor training for old people who are healthy or require a minimum amount of care.

#### **Methods**

#### **Subjects**

One hundred residents of an eldercare home (33 men, 67 women) aged  $\geq$  65 years old volunteered to participate in this study of the relationship between oral function and cognitive function. We excluded volunteers who were unable to communicate well. All subjects undertook the Mini-Mental State Examination (MMSE), and the oral, occlusal force, masticatory function, and oral diadochokinesis (ODK) examinations. The correlation of these factors was analyzed.

In a second study, we randomly selected five subjects from among those evaluated as having no cognitive impairment in first MMSE, and allocated them to the non-impairment group (NIG, n=5). Next, we randomly selected 10 subjects from among those evaluated

as having some cognitive impairment in the first MMSE, and allocated them to the impairment group (IG, n=10), Mild cognitive impairment (MCI, n=5), mild dementia (MD, n=3), and moderate dementia (MOD, n=2).

We did not include persons with severe dementia because it would have been difficult for them to participate in tongue and lip motor training on a daily basis.

The present study was approved by the Ethics Committee of Matsumoto Dental University (No. 258). Informed consent was obtained from all participants. This study followed the Declaration of Helsinki with regard to medical protocol and ethics.

## **Cognitive evaluation**

Cognitive function was measured using the MMSE, an instrument that has been used extensively in clinical and research settings [16]. The MMSE consists of 11 simple tasks grouped into seven cognitive domains:

- 1. Orientation to time
- 2. Orientation to place
- 3. Registration of three words
- 4. Attention and calculation
- 5. Recall of three words
- 6. Language
- 7. Visual construction

A maximum score of 30 was used to assess an individual's cognitive performance based on direct observation. The following five levels were employed to classify cognitive impairment:

- 1. No cognitive impairment 28–30 points
- 2. MCI 24-27 points
- 3. MD 21–23 points
- 4. MOD 11–20 points
- 5. Severe dementia  $\leq 10$

#### **Oral examination**

Three dentists examined the total number of present teeth and the use of dentures. Teeth with severe decay and stump teeth were not considered present teeth.

#### **Occlusal force**

Subjects were asked to bite the pressure sensitive film (Dental Prescale 50H Type R, GC, and Tokyo, Japan) with maximum force. If subjects habitually used their dentures, they bit the film wearing their dentures. Occlusal force was measured in Newtons (N) using a pressure-sensitive film and the associated analytical equipment (OCCLUZER 709, GC, and Tokyo, Japan).

#### **Masticatory function**

We measured subjects' masticatory function using xylitol check gum (LOTTE Co., Ltd, Tokyo), which changes color during the chewing process. After subjects had chewed the gum sixty times, the color of the gum was observed. Masticatory function was evaluated as per five phases each with a related score: 1. Green (score 1) means very poor mastication

- 2. Yellow green (score 2) means poor mastication
- 3. Light pink (scare 3) means normal mastication
- 4. Pink (score 4) means good mastication
- 5. Red (score 5) means very good mastication.

#### **Oral diadochokinesis**

The ODK rapid syllable repetition test was used to evaluate articulatory oral motor skill at sites such as the lips, tongue tip, and tongue dorsum. Subjects were asked to repeat each given syllable Pa, Ta and Ka sequentially and as fast as possible for five seconds. The number of repetitions per second were calculated using an electronic calculator via an internal microphone named Kenkoukun (Takei Scientific Instruments, Co., Ltd., Niigata, Japan). We measured the number of repetitions three times with 10-second intervals in between and calculated the mean value per one second. Furthermore, we calculated the average repetition time of three words and the value was used for the analysis of correlation and comparison.

#### Training

Subjects performed two kinds of training exercise three times per day before each meal. The first training exercise involved subjects keeping their mouths open for five seconds while holding their lower jaw with their hand and applying upward pressure. This training exercise was performed three times to prepare subjects for the next tongue and lip motor training.

The second training exercise was to pronounce the syllables, Pa, Ta, and Ka. Subjects rapidly repeated Pa for five seconds three times, with 10-second intervals. They then did the same for Ta and Ka in turn.

#### Statistical analysis

The correlations between MMSE, the number of present teeth, masticatory function, occlusal force, and ODK were tested using Spearman's rank correlation. Furthermore, the relations between each factor and MMSE scores were analyzed using a stepwise multiple regression analysis. To evaluate the effect of training, Friedman's one-way repeated measure analysis of variance test was used on the MMSE, occlusal force, masticatory function and ODK times. Thereafter, the Dunnet-test was used to compare the values of the groups during training. All statistical analyses were conducted using SPSS 23.0 and the results were considered significant at P < 0.05.

#### Results

#### Subject attributes

Subject characteristics are shown in table1. The mean  $\pm$  SD of MMSE scores was 23.36  $\pm$  5.97 points. The subjects evaluated by the MMSE were allocated to groups as follows: 33 subjects in the no cognitive impairment, 25 subjects in the MCI, 11 subjects in the MD, 27 subjects in the MOD, and 4 subjects in the severe dementia.

#### **Correlations between each factor**

As Table 2 shows, the MMSE scores were correlated with age (r=-0.428, P < 0.01), the number of present teeth (r=0.337, P < 0.01),

masticatory function (r=0.426, P < 0.01), and ODK (r=0.436, P < 0.01). There were also some correlations between other factors, (Table 2).

#### Connection with the MMSE score

From the results of the multiple regression analysis with MMSE scores as the dependent variable, cognition function was shown to be strongly related to age (t=-2.79, P<0.01) and ODK (t=2.28, P<0.05) (Table 3).

Table 1: Subject Characteristics.

Factor	Total (n=100)		
Age(years old)	78.43 ± 7.72		
Sex ( men/women )	33 / 67		
MMSE (score)	23.36 ± 5.97		
Number of present teeth	16.30 ±9.74		
Occlusal force (N)	380.54 ± 293.58		
Masticatory function ( score )	3.33 ± 1.10		
ODK ( time/s )	4.13 ±1.24		

Mean  $\pm$  SD, MMSE: Mini-mental state examination; ODK: Oral diadochokinesis.

 Table 2: Correlation of Each Parameter.

Factor	MMSE	Age	Number of present teeth	Occlusal force	Masticatory function
MMSE					
Age	- 0.428**				
Number of present teeth	0.337**	-0.237*			
Occlusal force	0.163	-0.173	0.533**		
Masticatory function	0.426**	-0.367*	0.375**	0.422**	
ODK	0.436**	-0.280*	0.372**	0.330**	0.499**

Values are presented as per the Spearman's rank-order correlation coefficient \*\*P < 0.01, \*P < 0.05

 Table 3: Multiple Regression Analysis with MMSE scores as the Dependent Variable.

Factor	β	standard error	standardizing coefficient	t value	p value	
Constant	31.01	8 6.72		4.62	0.00	
Age	-0.204	4 0.073	-0.269	-2.79	0.006**	
ODK	1.098	5 0.479	0.24	2.28	0.025*	

\*\*P < 0.01, \*P < 0.05.

# Effects of tongue and lip motor training Subjects

The mean age  $\pm$  SD of five subjects (one man, four women) in the NIG was 74.2 $\pm$ 6.8. Two of the ten subjects selected for the IG were hospitalized during the 15-month follow up, and so dropped out of the study. The mean age of the eight remaining subjects (4 men, 4 women) was 78.7 $\pm$ 6.5. There was no significant age difference among the subjects in the two groups.

#### **MMSE** scores

In the NIG, the median MMSE scores pre-training was 29, and the scores post after 3, 6, 9, 12 and 15-months of training were 28, 28, 30, 30 and 30, respectively. The Friedman–test results showed a significance level of P<0.005. However, the difference between each two periods was not significant as shown in Figure 1A.

In the IG, the median MMSE scores pre-training was 23.5, and the scores post after 3, 6, 9, 12 and 15-months of training were 23, 24.5, 25.5, 27 and 28.5, respectively. The Friedman-test results showed a significance level of P<0.005 for the IG. The scores post 15 months of training were significantly higher than the pretraining scores and the scores three months after training started (P<0.05), as shown in Figure 1B. Moreover, four subjects in the IG who were evaluated as having MCI before training improved in no cognitive impairment after 12 months of training. Two subjects in the MD moved up to the MCI and two subjects in the MOD moved up to the MD after 15 months of training.

## Occlusal force

In the NIG, the median scores for occlusal force before training was 369.7 N, and the scores after 3, 6, 9, 12 and 15-months of training were 176.9, 236.4, 255.8, 196.5 and 231.6 N, respectively. The Friedman–test results showed P<0.05 for the NIG, but, the differences between each two periods were not significant (Figure 2A).

In the IG, the median score for occlusal force before training was 330.3 N, and the scores after 3, 6, 9, 12 and 15-months of training were 298.0, 233.1, 183.9, 158.1 and 107.0 N, respectively. The Friedman–test results showed p<0.01 for the IG, but the differences between each two periods were not significant (Figure 2B).

#### **Masticatory function**

In the NIG, the median pre-training scores for masticatory function was 3, and the scores after 3, 6, 9, 12 and 15-months of training were 4, 4, 4, 4 and 5, respectively. The Friedman-test results showed P<0.005 and the score after 15-months of training was significantly higher than before training (p<0.045) (Figure 3A).

In the IG, the median pre-training scores for masticatory function was 3, and the scores after 3, 6, 9, 12 and 15-month of training were 4, 4, 4, 3 and 3, respectively. The results of the Friedman-test showed no significant difference for the pre and post training masticatory function scores (Figure 3B).



Figure 1: Comparison of MMSE scores between before and after pronunciation training.

A: non- impairment group B: impairment group \**P*< 0.05



Figure 2: Comparison of occlusal force between before and after pronunciation training. A: non- impairment group B: impairment group



Figure 3: Comparison of masticatory function between before and after pronunciation training. A: non- impairment group B: impairment group. \*P < 0.05



Figure 4: Comparison of ODK between before and after pronunciation training.

A: non- impairment group B: impairment group \*P< 0.05, \*\*p<0.01, \*\*\*p<0.005

#### **Oral diadochokinesis**

In the NIG, the median time for ODK before training was 3.9, and the times after 3, 6, 9, 12 and 15-month of training were 4.1, 4.4, 4.5, 4.6 and 5.2, respectively. The results of the Friedman–test showed a value of P<0.0001 for the NIG. The ODK times after 15 months of training were significantly higher than ODK times before training (p<0.01) and the times three months after training (p<0.005) (Figure 4A).

In the IG, the median time for ODK before training was 3.1, and the scores after 3, 6, 9, 12 and 15-month of training were 3.6, 3.8, 4.5, 4.1 and 5.2, respectively. The results of the Friedman-test showed a value of P<0.0001 for the IG. The ODK times after 15 months of training were significantly higher than the ODK times before training, and the ODK times three and six-months after training (p<0.05) (Figure 4B). In addition, there was a significant difference between the ODK times before training and the times 9 (p<0.05), 12 (p<0.01) and 15 (p<0.005) months after training (Figure 4B).

#### Discussion

This study analyzed the association between cognitive and oral functions. The MMSE scores showed a correlation with age, the number of present teeth, masticatory function, and ODK. The results suggest that tooth loss leads to poor masticatory function, which may negatively affect brain function. Loss of teeth increases the risks for deterioration of cognitive function [12]. Previous studies analyzed comparison values using odds ratios and reported

that dementia was associated with the number of teeth, oral hygiene, and bite force [17,18]. However, in this study, we found a positive correlation between the number of teeth and occlusal force, but no correlation between MMSE scores and occlusal force. The reason for these differences could be attributed to the use of different analysis methods.

The MMSE scores were strongly related to age and ODK. One study found that a decrease in oral motor dexterity could be an early signal of MCI, so its detection might improve the prognosis of dementia [19]. We also hypothesized that oral motor skills may improve dementia and maintain cognitive function. A decrease in cognitive function may be due to age and the natural passage of time, but the results in our study found that the pronunciation function, not age alone, was strongly related to cognitive function. It is possible that age-related decrease in the functions of the motor area in the cerebral cortex and the dexterity of the tongue were improved by 15 months of tongue and lip motor training.

Tongue and lip motor training as an exercise that engages oral motor skills was offered continuously for 15 months and was well received by the subjects in the elder care home. The MMSE scores of the subjects in the IG after 15-months of training were significantly higher than their scores before the training and after three-months of training. Moreover, all subjects in the IG improved in their cognitive function after 15 months of training. Tongue and lip motor training expands the dexterity of the tongue and lips, which then increase the activities of the neurons and network in the brain. Thus, continuous training contributes to improving cognitive function. However, we also found that the MMSE scores of subjects in the NIG were not always stable. This finding could be due to physical and mental conditions brought on by depressive symptoms [20]. Therefore, it is necessary for old people to maintain a good physical state and a comfortable environment so as to maintain their brain functions. Overall, these results demonstrate that pronunciation training induces a positive effect on the cognitive function of patients with dementia and poor cognition.

In both the IG and NIG, subjects' ODK scores after 15-months of training were significantly higher than their times before the training and after three months of training. Subjects' ODK times are used to evaluate oral motor skills. In Japan, "pa/ta/ka/ra" is used to create tongue movements to maintain swallowing function in the elderly [21]. Previous studies found that singing can enhance motor neurons associated with tongue and lip movements [22]. The tongue and lip motor training increased the movements of the tongue and the orbicularis oris muscle, which then improved subjects' pronunciation.

There are no significant differences between the occlusal force values of the two groups. The value of occlusal force shows a decreasing tendency in repeated measurement during training. The power of masticatory muscles may decrease with age [23], which induces the tendency to decrease occlusal force. This suggests that pronunciation training cannot always strengthen masticatory muscles. One the other hand, the masticatory function of all subjects increased. However, when comparing each measurement, we found that they did not differ significantly from each other. These results demonstrate that masticatory function and occlusal force may be associated with the number of present teeth and the power of the masticatory muscle. Thus, it is necessary for the elderly to maintain masticatory function to eat sufficient nutritious food [12]. If, not, they will need further training to enhance masticatory function.

Physical exercise such as aerobic exercise is recommended to prevent dementia as per clinical practice guidelines [24,25]. This is because physical activity protects against the loss of gray and white brain matter and reduces neurotoxic factors [26]. Audiovisual integrative training such as music therapy with digital devices can positively affect executive function and induce an improvement in memory, which can then increase MMSE scores [27]. Pleasant stimulation and physical activity activate the brain; stress promotes the pathogenesis of dementia, which is associated with decreased sociability and depression [28]. Therefore, emotion is the most important factor in the daily life of old people. As it is relatively easy and affordable to participate in music therapy and tongue and lip motor training at home, the combined method could be effective for enhancing cognitive function in the old people.

Many studies show that oral function is an important factor in maintaining cognitive function [12,13,17,18] and that intervention programs improve the cognitive function of patients with MCI [2,10,19]. However, our study found that advanced dementia, MD

and MOD, were improved by 15 months of tongue and lip motor trainings. Our results also suggested that cognitive function may be improved by strengthening the muscle in the oral maxilla facial area by adding more teeth. This further suggests that cognition function in older people may be related to oral function, as measured by the frequency of pronunciations.

However, as there were just 100 subjects in this study, a small percentage of the elderly population of Japan, it will be necessary to verify these effects using many more subjects in a future study.

# Conclusion

In this study, 15 months of tongue and lip motor training was found to be effective for improving cognitive and pronunciation functions. Tongue and lip motor training increased the MMSE scores of subjects with MCI and mild and moderate dementia, and the pronunciation frequency of all subjects. These results suggest that pronunciation training can enhance the activity of the tongue and orbicularis oris muscle and enhance their dexterity, which can then improve cognitive function.

# Acknowledgements

This study was supported by the institution for old people organized by social welfare corporation, "Toukoukai". The authors are grateful to all subjects, care managers, and care helpers who participated in this study.

# References

- 1. Easter ling CS , Robbins E. Dementia and dysphagia. Geriatr Nurs. 2008; 29: 275-285.
- Moro V, Condoleo MT, Valbusa V, et al. Cognitive stimulation of executive functions in mild cognitive impairment specific efficacy and impact in memory. Am J Alzheimers Dis Other Demon.? 2015; 8: 153-164.
- 3. Nouchi R, Taki Y, Takeuchi H, et al. Reading Aloud and Solving Simple Arithmetic Calculation Intervention Learning Therapy Improves Inhibition Verbal Episodic Memory Focus Attention and Processing Speed in Healthy Elderly People Evidence from a Randomized Controlled Trial. Front Hum Neurosci. 2016; 17: 217.
- 4. Verghese J, Lipton RB, Katz MJ, et al. Leisure activities and the risk of dementia in the elderly. N Engl J Med. 2003; 348: 2508-2216.
- Yates LA, Ziser S, Spector A, et al. Cognitive leisure activities and future risk of cognitive impairment and dementia systematic review and meta-analysis. Int Psychogeriatr. 2016; 28: 1791-1806.
- 6. Aguirre E, Woods RT, Spector A, et al. Cognitive stimulation for dementia a systematic review of the evidence of effectiveness from randomised controlled trials. Ageing Res Rev. 2013; 12: 253-262.
- 7. Kim MJ, Tsutsumimoto K, Doi T, et al. Relationships between cognitive leisure activities and cognitive function in older adults with depressive symptoms a cross-sectional study. BMJ

Open. 2020; 10: e032679.

- 8. Moreira SV, Justi FRDR, Moreira M. Can musical intervention improve memory in Alzheimer's patients. Evidence from a systematic review. Dement Neuropsychol. 2018; 12: 133-142.
- 9. Clark IN, Taylor NF, Baker F. Music interventions and physical activity in older adults a systematic literature review and meta-analysis. J Rehabil Med. 2012; 44: 710-719.
- 10. Shimizu N, Umemura T, Matsunaga M, et al. Effects of movement music therapy with a percussion instrument on physical and frontal lobe function in older adults with mild cognitive impairment a randomized controlled trial. Aging Ment Health. 2018; 22: 1614-1626.
- 11. Dowson B, McDermott O, Schneider J. What indicators have been used to evaluate the impact of music on the health and wellbeing of people with dementia. A review using metanarrative methods. Maturitas. 2019; 127: 26-34.
- 12. Takeuchi K, Ohara T, Furuta M, et al. Tooth Loss and Risk of Dementia in the Community: the Hisayama Study. J Am Geriatr Soc. 2017; 65: e95-e100.
- Saito S, Ohi T, Murakami T, et al. Association between tooth loss and cognitive impairment in community-dwelling older Japanese adults a 4-year prospective cohort study from the Ohasama study. BMC Oral Health. 2018; 18: 142.
- 14. Namiki C, Hara K, Tohara H, et al. Tongue-pressure resistance training improves tongue and suprahyoid muscle functions simultaneously. Clin Interv Aging. 2019; 14: 601-608.
- 15. Kim HD, Choi JB, Yoo SJ, et al. Tongue-to-palate resistance training improves tongue strength and oropharyngeal swallowing function in subacute stroke survivors with dysphagia. J Oral Rehabil. 2017; 44: 59-64.
- Perneczky R, Wagenpfeil S, Komossa K, et al. mapping scores onto stages mini-mental state examination and clinical dementia rating. Am J Geriatr Psychiatry. 2006; 14: 139-144.
- 17. Miura H, Yamasaki K, Kariyasu M, et al. Relationship between cognitive function and mastication in elderly females. J Oral Rehabil. 2003; 30: 808-811.
- 18. Morishita S, Watanabe Y, Ohara Y, et al. Factors associated with older adults' need for oral hygiene management by dental

professionals. Geriatr Gerontol Int. 2016; 16: 956-962.

- 19. Watanabe Y, Arai H, Hirano H, et al. Oral function as an indexing parameter for mild cognitive impairment in older adults. Geriatr Gerontol Int. 2018; 18: 790-798.
- 20. Wilson RS, Capuano AW, Boyle PA, et al. Clinical-pathologic study of depressive symptoms and cognitive decline in old age. Neurology. 2014; 83: 702-709.
- 21. Nishio M, Niimi S. Changes in speaking fundamental frequency characteristics with aging. Folia Phoniatr Logop. 2008; 60: 120-127.
- 22. Mori T, Yoshikawa M, Maruyama M, et al. Development of a candy-sucking test for evaluating oral function in elderly patients with dementia A pilot study. Geriatr Gerontol Int. 2017; 17: 1977-1981.
- 23. Van Dam R, Van Ancum JM, Verlaan S, et al. Lower Cognitive Function in Older Patients with Lower Muscle Strength and Muscle Mass. Dement Geriatr Cogn Disord. 2018; 45: 243-250.
- 24. Öhman H, Savikko N, Strandberg TE, et al. Effect of physical exercise on cognitive performance in older adults with mild cognitive impairment or dementia a systematic review. Dement Geriatr Cogn Disord. 2014; 38: 347-365.
- 25. Barnes DE, Santos-Modesitt W, Poelke G, et al. The Mental Activity and eXercise MAX trial a randomized controlled trial to enhance cognitive function in older adults. JAMA Intern Med. 2013; 173: 797-804.
- 26. Cheng ST. Cognitive Reserve and the Prevention of Dementia the Role of Physical and Cognitive Activities. Curr Psychiatry Rep. 2016; 18: 85.
- 27. Lee LP, Har AW, Ngai C, et al. Audiovisual integrative training for augmenting cognitive-motor functions in older adults with mild cognitive impairment. BMC Geriatrics. 2020; 20: 64.
- Wilson RS, Boyle PA, James BD, et al. Negative social interactions and risk of mild cognitive impairment in old age. Neuropsychology. 2015; 29: 561-570.

© 2021 Innami M, et al. This article is distributed under the terms of the Creative Commons Attribution 4.0 International License