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Eye Movement Program Consisting of Saccadic Eye Movement and Pursuit Eye Movement Improved Visual Memory in Institutionalized Elderly Person: Randomized controlled pilot study

Background: Aging reduces cognitive abilities, including visual memory (VM) and visual discrimination (VD). Since common cortical networks subserve eye movement and attention, voluntary eye movement may improve visual attention. Visual selective attention was major role for memory, and visual memory and visual attention are intimately related.
Objective: To identify the improvement in VD and VM, after implementing the eye movement program consisting of saccadic eye movement (SEM) and pursuit eye movement (PEM) in the institutionalized healthy elderly.
Design: Randomized controlled trial.
Methods: The study involved a sample of 36 participants, and the mean age was 79.03 years (range 76~84 years). They were randomly allocated to the experimental group (n=16) and control group (n=20). Participants in the experimental group performed SEM 5 times per week for 4 weeks: twice daily at the same time in the morning and afternoon. The program was carried out for 3 minutes, and it consisted of SEM and PEM. The target's moving frequency was set at 0.5 Hz. VM and VD at the baseline and post-intervention were measured using Motor-Free Visual Perception test-4 (MFVPT-4).
Results: VM significantly improved in the experimental group ($p < .01$), and significant differences were observed compared to the control group ($p < .01$). There was no significant change in VD.
Conclusion: The eye movement program consisting of SEM and PEM increased VM more than VD. Therefore, eye movement program was feasible interventions for improving VM in institutionalized elderly persons.

Key words: *Saccadic eye movement; Pursuit eye movement; Visual memory; Institutionalized elderly*

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INTRODUCTION

Humans make use of visual selective attention in an effort to prevent the disruption of environmental information. The stability of the visual system is reviewed as an adaptation to a stable environment and instances of perceptual learning as a reaction of the brain to abrupt changes in the environment. [1] Visual attention is an important factor that enables us to understand external environments and help our proper adaption, and furthermore, it may be associated with visual perception. Aging also results in a decline in a number of cognitive abilities, such as memory and attention. [2] Specifically, visual memory is one of the several cognitive abilities, and is strongly linked to attention. [3] In this context, the degeneration of age-related visual attention may influence visual memory.

To identify the surrounding environments and respond to visual stimuli, voluntary or involuntary eye movements should be triggered, and visual attention is an important mechanism in generating voluntary eye movement. [4] Eye movements are of two types: pursuit eye movement (PEM) and saccadic

eye movement (SEM). PEM is defined as a conjugate eye movement which smoothly tracts slowly moving targets in the visual field, and SEM is a rapid eye movement where both eyes move together in the same direction. [5] Eye movement is a commonly used method to explain neuropsychological processes, such as attention, spatial memory, and decisional processes. [6] Voluntary eye movement and directing attention are a common circuit, and common cortical networks subserve oculomotor functions and spatial attention in humans. [4, 7] Young and older adults performed similarly on the easy version of the task, most older adults were impaired relative to young participants when the number of overlapping features increased. [8] The previous reports suggest that eye movement may be a critical factor to elderly people who suffer from the degeneration of visual discrimination (VD) as well as declined visual attention and visual memory (VM). [8, 9] Also, eye movement suggested screening assessment for cognitive decline, such as VD and VM, in older adults. [10] Nonetheless, studies of VM and VD in older populations are limited in spite of the rapidly increasing world average life expectancy of humans.

The aim of this study was to identify the feasibility of eye movement program consisting of SEM and PEM on VM and VD in institutionalized elderly persons. This study hypothesized that SEM and PEM would improve visual memory and visual discrimination in institutionalized elderly persons.

SUBJECTS AND METHODS

Participants

Design of this study is controlled randomized and pilot trial. Participants were 46 institutionalized elderly persons participated who blinded to the purpose of this study. The participants met the following inclusion criteria: (1) no report dizziness; (2) the Mini-Mental State Examination score 〉 24; (3) no visual or auditory deficits. Patients who had preexisting neurological disorders, progressive disease, or other concurrent medical conditions, and not perform the intervention twice daily for 3 minutes were excluded. Participants were randomly assigned to the experimental and control groups. Ten participants (experimental 7, control 3) excluded from the study. They either had dizziness and personal problem, and not performed the study procedure during the study period. Figure 1 described the study procedure. A total 36 elderly (79.03 years, range 76-84 years, 7 men

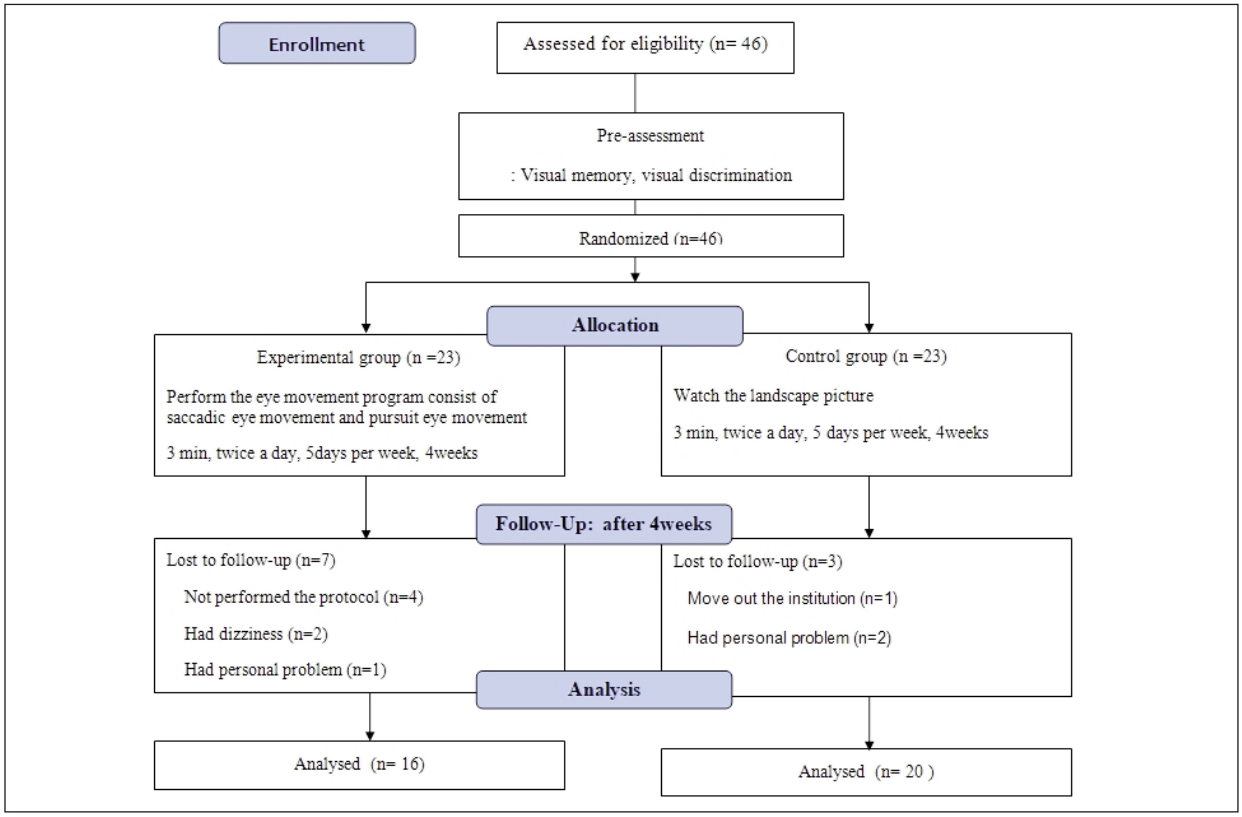

Fig. 1. Flowchart of this study.

and 29 women) participated in the study. Visual memory and discrimination tests were carried out before and after the study. According to the previously described method. [10] The participants signed a written consent approved by the local ethics committee. The study was approved by the Institutional Review Board Ethic Committee of Gachon University (044396-201602-HR-012-01).

Intervention

All participants sat on a chair with a backrest device and watched the monitor while sitting on a chair placed 2 m away from a 24-inch television (a liquid crystal display [LCD] monitor [27.5 cm × 30 cm, LT24E395KD, Samsung]). The monitor was positioned at eye level in a noise-free environment to allow the participants to concentrate on the intervention. In the experimental group, participants were instructed to trace a moving target presented at eye level on a computer screen, without moving any head and trunk. The target was a red dot of 2 cm in length, moving on a white background. The moving target was prepared by Adobe Flash software on the monitor.

Eye movement program consisted of SEM and PEM; in SEM, eye saccades were performed in a manner directed to a target appearing on one side of monitor, and in PEM, the eye pursued a target moving in a lateral or vertical direction irregularly from one side to the other side of the monitor. To minimize the movement of the head during the intervention, the total distance of the monitor was set to only allow an 11° field of vision. [11, 12] The target's moving frequency was set at 0.5 Hz, and the target was then set to reappear randomly in a horizontal or vertical location, based on prior work. [11, 13] The duration of eye movement were 3 minutes, which according to a pilot study conducted on 5 participants, was found to be the optimal duration that does not cause any dizziness or discomfort for participants.

The control group watched a landscape picture video. The landscape picture video consisted of only landscape pictures with no human or animal movements. All participants performed the intervention for approximately 3 minutes, 5 days per week, for 4 weeks; twice daily at the same time, morning and afternoon during the daily life.

Measurement outcome

Visual memory and visual discrimination was measured using Motor-Free Visual Perception test-4 (MVPT-4). MVPT-4 provides a quick, reliable, and valid measure of overall visual perceptual ability in under 4 years through over 80 years, and is a visual perceptual assessment that can be suitable in clinical practice with better reliability and validity. [14] Visual memory measured a 9-item, the subscales of MVPT-4. Visual discrimination measured 9-item spatial relationship and a 9-item visual discrimination, the subscales of MVPT-4. If the participant fails to answer a given item within 30 seconds, or respond time is over 30 seconds, we assessed the item was erroneous and measured as row score.

Statistical Analysis

All statistical analyses were performed with the SPSS (version 21.0). General characteristics of the participants were presented by descriptive statistics. The Shapiro-Wilk test was conducted to check the normality of the outcome variables. Student's paired t-test was performed to compare intra-group dependent variables, and inter-group dependent variables were compared by independent t-test. All variables were expressed as mean ± SD. The significance level was set to α=.05.

RESULTS

Baseline characteristics of the participants (n=36) are presented in Table 1. No significant differences

Table 1. Baseline characteristics of the participants

		Experimental group (n = 16)	Control group (n = 20)	p
Sex	Male	4	3	.592
	Female	12	17	
Age (year)		78.89 ± 4.16	79.15 ± 3.23	.826
Height (cm)		153.61 ± 6.67	151.10 ± 4.49	.178
Weight (kg)		56.37 ± 8.14	57.33± 6.59	.690

Values are presented as Means ± SD

Table 2. Comparisons visual memory and visual discrimination between before and after intervention

Variables	Experimental group			Control group			
	Baseline	4 weeks	Change (CI)	Baseline	4 weeks	Change (CI)	Between group change (CI)
Visual memory	4.94±0.38	6.72±0.29	1.78(1.17, 2.38)*	5.40±6.24	5.35±0.42	−.05(−.49, −.39)	1.83 (1.11, 2.54)*
Visual discrimination	10.44±0.45	10.67±0.44	.22 (−0.25, 0.69)	10.20±0.63	10.05±0.62	−.15(−.82, .52)	.80 (.17, 1.42)

*p〈0.05, Abbreviation: CI, confidential interval.

were observed between the experimental and control groups for sex, age, height, and weight. All dependent variables have a normal distribution. VD scores significantly increased in the experimental group ($p < .01$). But, there was no changed in the control group. VD in experimental group was significantly better than those in the control group ($p < .05$). Visual discrimination was not change (Table 2).

The results suggest that an eye movement program offered more positive impacts to visual memory than to visual discrimination.

DISCUSSION

The aim of this study was to identify the feasibility of eye movement program consisting of SEM and PEM on VM and VD in institutionalized elderly persons. Our hypothesis was that SEM would improve both VM and VD. However, our results indicate that only VM improved.

Age related changes have been observed in attention, which is necessary for adaptation to external environments in daily life. [15, 16] Attention or memory deficit is correlated with normal aging. [17] Eye movement pattern is associated with cognitive decline in the elderly. [18] Oculomotor dysfunction is especially observed in Alzheimer's disease, showing a cognitive decline. [19, 20] This represents that cognition is a critical variable that affects eye movements and attention is associated with eye movement strategies, face recognition, and depletes cognitive resources. and face recognition, and depletes cognitive resources such as attention and memory. [8, 21] In our study, participants had a MMSE score 〉24 that suggest normal cognition. [22] Therefore, authors suggested that participants of this study did not affect the performance of eye movement. Thus, authors believe that since cognitive functions such as attention and memory are closely associated with eye movement, cognitive ability may be improved through stimulation of eye movements. The results of this study demonstrated that a 4-week eye movement program served to significantly improve visual memory in institutionalized elderly persons. Our finding are similar to prior studies revealing improvement of visual attention and working memory through a web-based training program in healthy adults, following the visual attention test. [23] In the present study, eye movement program performed that comprised of SEM and PEM. Specifically, SEM is proven to be an influential method to investigate visual attention [24] and memory. [25] When both SEM was performed, common cortical networks also subserve oculomotor functions and spatial attention in humans. [7] Only recently has it been shown that there is actually a large overlap in the neural circuits controlling saccades. [26] The authors assumed that the voluntary eye movement program consisting of SEM contributed to improving visual attention in institutionalized elderly persons, with positive impacts on their visual memory.

Previous studies have reported the correlation between eye movements and visual perception, and there are many benefits of eye movements for visual perception such as visual memory and discrimination. [27] Also, aging alters visual discrimination such as the detection of linked contour and discrimination of closed shape. [28, 29] Interestingly, greater deficits were manifest for the discrimination of shape from texture than for the discrimination of closed contours. [30] In the present study, visual discrimination was not changed. Differences in stimulus visibility were due to poorer optics and neural changes. Especially, older subjects required longer stimulus presentations to discriminate of contours, and older adults had more elevated shape discrimination thresholds than young adults. [30] Age-related macular degeneration showing increased incidence than normal aging, having significant deficits in performing the global shape-discrimination task. [31] Thus, poorer optics and neural changes in older adults are influencing factors that affect visual discrimination. However, our study did not consider any ocular state of participants, such as visual acuity and macular degeneration. In this context, visual discrimination is more significantly

affected by poorer optics and neural changes than eye movements.

Although this study achieved the aims, it has few limitations. The authors used self-reported measurement on visual memory and discrimination. In addition, the study period was relatively short by performing the institutionalized elderly persons for 4 weeks. Despite the aforementioned limitations, there are also important strengths to this study. This study found that the SEM improved visual memory more than visual discrimination. The results also indicate that changes in visual discrimination are insignificant in the experimental group when compared to visual memory, but significant differences in visual discrimination are noted between the two groups. Thus, authors propose that further studies are required to consider the ocular state of participants, such as visual acuity and macular degeneration, and the study period as well. In addition, since age-related declines in attention most significantly alter function, [32] visual attention is significantly related to mobility dysfunction. [33] In future studies, the authors will investigate the changes in mobility function and visual perception after application of the eye movement program in the elderly.

CONCLUSION

The present finding identified that visual memory could be improved after applying eye movement program for 4 weeks in institutionalized elderly persons. Therefore, eye movement program consisting of SEM and PEM was feasible intervention for improving VM in institutionalized elderly persons.

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Declaration of Conflicting Interests

The authors in this study declare that there is no conflict of interest.

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