

Effects of Visual Biofeedback Training for Fall Prevention in the Elderly

KWON-YOUNG KANG, PhD, PT¹⁾

¹⁾ Department of Physical Therapy, Seonam University: Gwangchi-dong, Namwon-si, Jeollabuk-do 590-711, Republic of Korea

Abstract. [Purpose] The purpose of this study was to investigate the effects of six weeks of visual biofeedback training for prevention of falling in the elderly. The Tetrax system was used for visual biofeedback training. [Subjects and Methods] Thirty elderly persons (experimental group=15, control group=15) who were above 70 and under 80 years of age participated in biofeedback training. They were trained for 15 minutes a day, three times per week. We measured the weight distribution index, stability index, and fall index in the subjects using the Tetrax system, and paired t-tests were used to evaluate the changes before and after intervention. The difference between the groups was compared using an independent t-test. [Results] The experimental group showed significant differences in weight distribution index, stability index, and fall index. The control group showed no significant differences. According to the comparison of training effects between the two groups, the variables of stability index and fall index revealed a statistically significant difference. [Conclusion] The method of visual biofeedback training used in this study should be considered a therapeutic method for the elderly to improve weight distribution, stability, and effectiveness in preventing falls.

Key words: Biofeedback, Elderly, Fall prevention

(This article was submitted May 9, 2013, and was accepted Jun. 4, 2013)

INTRODUCTION

In general, aging is accompanied by stamina reduction and overall physiological malfunctioning, and as a result, the elderly are destined to suffer from deterioration of control of eye direction or physical balance due to pose unbalance, increasing the risk of falling¹⁾.

Falling happens when a part of the human body touches the floor due to loss of balance or stability without any external shock in daily life²⁾ or due to loss of consciousness, and this results in physical injury, reduction of activity, loss of self-confidence, and lifestyle changes in the victim, especially in the elderly^{3,4)}. Past research has revealed postural control ability reduction⁵⁾, postural change increase⁶⁾, dynamic balance ability reduction⁷⁾, walking speed and reduction of mobility⁸⁾, reduction of strength of lower extremities⁹⁾, and ability to stand up from chairs¹⁰⁾ as reasons why the elderly fall.

Elderly individuals who have fallen before have been reported to be reluctant to perform daily life activities due to the limitations of daily life motions and fear of falling¹¹⁾. In this case, exercise is absolutely indispensable, since such unwillingness to move deteriorates muscular strength,

balance ability, and stamina while raising the falling risk, which ultimately results in a vicious cycle. Elderly individuals with a lack of exercise may develop amyotrophia or low bone density¹²⁾ and lose their stamina rapidly, including muscular strength, flexibility, quickness, and balance, causing enormous trouble in their daily lives¹³⁾. On the other hand, exercise is effective not only for reducing the risk of cardiovascular diseases, diabetes, high blood pressure, and obesity but also for increasing bone density and muscle mass¹⁴⁾. Furthermore, movement control induces a response to the course of feedback and feedforward. We found that it is necessary to coordinate the sensory and motor by synthetic interaction of the musculoskeletal system and nervous system for movement control and also that the sensory input affects balance in the elderly^{15, 16)}. In conclusion, to improve the postural control capability to prevent falling, an all-purpose exercise program that provides accurate information via sight, vestibular senses, and somesthesia is desperately needed to seek the most suitable posture for the nervous system and simultaneously improve exercise response and musculoskeletal flexibility.

The aim of this research was to verify that visual biofeedback training is effective for preventing age-initiated muscular strength deterioration and flexibility loss, because they can increase the risk of falling.

SUBJECTS AND METHODS

Subjects

The subjects for this study were elderly individuals

*Corresponding author. Kwon-Young Kang (e-mail: k2y1125@hotmail.com)

©2013 The Society of Physical Therapy Science

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License <<http://creativecommons.org/licenses/by-nc-nd/3.0/>>.

above 70 but under 80 years of age. A total of 30 people were selected. The subjects were divided randomly into two groups to minimize selection bias. The subjects fully understood the objectives of the study and voluntarily consented to participate. They also met the inclusion criteria: no problems with their musculoskeletal system, capable of independent walking, and no problems with vestibular and cognitive ability. The study period was 6 weeks from April 2013 to June 2013. Prior to participation in the study, written informed consent, accepted by the local ethics committee, was obtained from all subjects. General characteristics of the subjects are shown in Table 1. For the experimental group, the mean age \pm SD was 74.04 ± 1.23 , and the mean weight \pm SD was 63.32 ± 4.10 . There were 9 males and 6 females. For the control group, the mean age \pm SD was 72.12 ± 2.63 , the mean weight \pm SD was 67.51 ± 2.34 , and there were 8 males and 7 females.

Methods

A Tetrax system (Sunlight, Petach Tikva, Israel), which is designed to measure the degree of risk of falling or the status of physical balance using a force plate, was used in this research. It was able to support the weight in each force plate and could be used to inspect a subject's balance and to execute biofeedback training using a monitor situated in front of the subject. In this research, the individuals in the experiment group selected a biofeedback program, Skyball, Gotcha!, Speedball, Tag, Speedtrack Horizontal, Speedtrack Vertical, Maze, Freeze, Target, or Immobilizer, at his or her discretion and exercised for 15 minutes, while the individuals in the control group exercised one leg while standing for 15 minutes and then switched legs. Next, their weight distribution index, stability index, and fall index were evaluated. The experiment was conducted 3 times a week over a 6-week period. It appeared that the fluctuation of the weight % on the force plate increased as the weight distribution increased and that the degree of imbalance

increased as the stability index increased. The fall index values were classified as 0–35=low risk, 36–57=moderate risk, and 58–100=high risk. SPSS version 12.0 was used for statistical analysis. The paired t-test was performed to examine changes within each group after treatment. The independent t-test was used for inter-group comparison. The level of statistical significance was $\alpha=0.05$.

RESULTS

In regard to the changes observed in the subjects, the experimental group showed statistically significant changes in weight distribution index, stability index, and fall index ($p<0.05$). The control group showed no significant increases in any items ($p>0.05$). According to the comparison of training effects between the two groups, there were statistically significant differences in the variables of stability index and fall index ($p<0.05$) (Table 2).

DISCUSSION

Balance is an essential element for functional activity, and we regarded balance ability as a critical factor involved in the daily lives of the elderly. Judge et al. reported that functional capabilities like walking, motility, and instrumental daily life motions are closely related to balance ability¹⁷). In other words, balance ability and falling are dependent on how the body copes with sudden imbalance. When the body experiences loss of balance suddenly, the quickness and balance ability of the upper and lower parts of the body interact, and muscular strength plays a key role in maintaining balance ability¹⁸). With advancing years, muscular strength is decreased, and falling occurs more frequently. In addition, the elderly lose muscular tissue, bone mass, and energy and suffer from deterioration of mobility and abnormal musculoskeletal systems, eventually losing balance ability. In particular, it has been reported that deterioration of the strength of the lower extremities quadruples the risk of falling and that a shortage of falling experience, walking, and balancing ability triples the risk of falling¹⁹). It has been reported many times in previous research that muscular strength and balance are deeply involved in falling^{6, 18}). In addition, other studies revealed that age is inversely proportional to the balance ability^{20–22}). According to the research of Choi²³), Tai Chi exercise contributed to significant improvement in the prevention of falling for the elderly over the age of 60, and according to the research of Nelson et al.²⁴), Tai Chi exercise at home for

Table 1. General characteristics of subjects

Characteristics	Biofeedback group (n=15)	Control group (n=15)
Age (yrs)	74.04 \pm 1.23	72.12 \pm 2.63
Weight (kg)	63.32 \pm 4.10	67.51 \pm 2.34
Sex		
Male	9	8
Female	6	7

Table 2. Comparison of measurement parameters of the groups

	Biofeedback group (n=15)		Control group (n=15)	
	Pre	Post	Pre	Post
WDI	6.90 \pm 1.90 ^a	5.86 \pm 1.61 [§]	6.27 \pm 1.68	5.66 \pm 1.49
SI ^o	17.77 \pm 4.94	13.57 \pm 3.50 [§]	15.73 \pm 4.37	15.20 \pm 3.64
FI ^o	57.60 \pm 18.80	48.46 \pm 15.48 [§]	60.66 \pm 23.46	59.19 \pm 22.69

^a Mean \pm SD. WDI, weight distribution index; SI, stability index; FI, fall index.

[§] Significant difference from before intervention (pre; $p<0.05$). ^oSignificant difference between the groups ($p<0.05$)

6 continuous months contributed to improving the balance of the elderly over the age of 70. Also, when we had elderly individuals over the age of 65 perform exercise for 12 weeks with a seniorobic program, the strength of their lower extremities increased, the interval between standing up and sitting down was reduced, and flexibility was significantly improved, supporting the results of the research mentioned above²⁵). The elements for balance improvement are sight, vestibular sense, and somesthesia organization for the control of stability, musculoskeletal system flexibility²⁶). Visual biofeedback training is thought to help improve balance by sensory integration because it generates righting reflex and trunk reactions via visual information, and uses feedback and feedforward against body movement.

This research has a limitation in that it only surveyed general citizens without regard to their individual levels of muscular strength even though balance is closely related with muscular strength. In future research, it is recommended to verify the visual biofeedback training effects in elderly individuals who have experience falling.

REFERENCES

- 1) Gauchard GC, Gangloff P, Jeanel C, et al.: Physical activity improves gaze and posture control in the elderly. *Neurosci Res*, 2003, 45: 409–417. [[Medline](#)] [[CrossRef](#)]
- 2) Lord SR, Clark RD, Webster IW: Physiological factors associated with falls in an elderly population. *J Am Geriatr Soc*, 1991, 39: 1194–1200. [[Medline](#)]
- 3) Campbell AJ, Borrie MJ, Spears GF, et al.: Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. *Age Ageing*, 1990, 19: 136–141. [[Medline](#)] [[CrossRef](#)]
- 4) Tinetti ME, Baker DI, McAvay G, et al.: A multifactorial intervention to reduce the risk of falling among elderly people living in the community. *N Engl J Med*, 1994, 331: 821–827. [[Medline](#)] [[CrossRef](#)]
- 5) Tinetti ME, Williams TF, Mayewski R: Fall risk index for elderly patients based on number of chronic disabilities. *Am J Med*, 1986, 80: 429–434. [[Medline](#)] [[CrossRef](#)]
- 6) Campbell AJ, Borrie MJ, Spears GF: Risk factors for falls in a community-based prospective study of people 70 years and older. *J Gerontol*, 1989, 44: M112–117. [[Medline](#)]
- 7) Wolfson LI, Whipple R, Amerman P, et al.: Stressing the postural response: a quantitative method for resting balance. *J Am Geriatr Soc*, 1986, 34: 845–850. [[Medline](#)]
- 8) Himann JE, Cunningham DA, Rechnitzer PA, et al.: Age-related changes in speed of walking. *Med Sci Sports Exerc*, 1988, 20: 161–166. [[Medline](#)] [[CrossRef](#)]
- 9) Kerrigan DC, Todd MK, Croce UD, et al.: Biomechanical gait alterations independent of speed in the healthy elderly: evidence for specific limiting impairments. *Arch Phys Med Rehabil*, 1998, 79: 317–322. [[Medline](#)] [[CrossRef](#)]
- 10) Lord SR, Murray SM, Chapman K, et al.: Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. *J Gerontol*, 2002, 57: M539–543. [[CrossRef](#)]
- 11) King MB, Tinetti ME: Falls in community dwelling older persons. *J Am Geriatr Soc*, 1995, 43: 1146–1154. [[Medline](#)]
- 12) Jessup JV, Horne C, Vishen RK, et al.: Effects of exercise on bone density, balance, and self efficacy in older woman. *Riol Res Nurs*, 2003, 4: 171–180. [[CrossRef](#)]
- 13) Tideiksaar R: *Falling in old age: Its prevention and treatment*, 2nd ed. New York: Springer, 1997, pp 28–34.
- 14) Lexell J, Taypor T: Variability in muscle fiber areas in whole human quadriceps muscle: effect of increasing age. *J Anat*, 1991, 174: 239–249. [[Medline](#)]
- 15) Woollacott MH, Shumway-Cook A: Changes in posture control across the life span: a systems approach. *Phys Ther*, 1990, 70: 799–807. [[Medline](#)]
- 16) Woollacott MH, Shumway-Cook A, Nashner LM: Aging and posture control: changes in sensory organization and muscular coordination. *Int J Aging Hum Dev*, 1986, 23: 97–114. [[Medline](#)] [[CrossRef](#)]
- 17) Judge J, Lindsey C, Underwood M, et al.: Balance improvement in older women: difficulties of exercise training. *Phys Ther*, 1993, 73: 253–262.
- 18) Avlund K, Scholl M, Davidson M: Maximal isometric muscle strength and functional ability in daily activities among 75-year old men and women. *Scand J Med Sci Sports*, 1994, 4: 32–40. [[CrossRef](#)]
- 19) Rao SS: Prevention of falls in older patients. *Am Fam Physician*, 2005, 72: 81–88. [[Medline](#)]
- 20) Duncan PW, Weiner DK, Chandler J: Functional reach: a new clinical measure of balance. *J Gerontol*, 1990, 45: M192–197. [[Medline](#)] [[CrossRef](#)]
- 21) Hageman PA, Leibowitz JM, Blanke D: Age and gender effects on postural control measures. *Arch Phys Med Rehabil*, 1995, 76: 961–965. [[Medline](#)] [[CrossRef](#)]
- 22) Myers AH, Baker SP, Van-Natta ML: Risk factors associated with falls and injuries among elderly institutionalized persons. *Am J Epidemiol*, 1991, 133: 1179–1190. [[Medline](#)]
- 23) Choi JH: The effects of Tai Chi exercise on physiologic, psychological functions, and fall in fall prone elderly. Unpublished doctoral dissertation, The Catholic University of Korea, 2002.
- 24) Nelson ME, Layne JE, Bernstein MJ, et al.: The effects of multidimensional home-based exercise on functional performance in elderly people. *J Gerontol A Biol Sci Med Sci*, 2004, 59: M154–160. [[Medline](#)] [[CrossRef](#)]
- 25) Byun YH, Choi KS: Effect of seniorobic program on physical function and fall in elderly. *Korean J Adult Nurs*, 2009, 21: 13–22.
- 26) Tink M, Mary K: *Neurologic Interventions for Physical Therapy*, 2nd ed. Philadelphia: Saunders Elsevier, 2007, pp 31–53.