

# The effects of proprioceptive neuromuscular facilitation integration pattern exercise program on the fall efficacy and gait ability of the elders with experienced fall

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The purpose of this study is to investigate the effect of exercising program utilizing proprioceptive neuromuscular facilitation integration pattern (PIP), which is effective in improvement of the physical function, on the fall efficacy and gait ability of the elders who experienced injuries from falls. Also, this study aims to investigate the applicability of exercise program as methods for fall reoccurrence prevention and physical functions enhancement. The subjects of the study were 30 elders in the local community with experience of injuries from falls. The period of the study was 4 weeks with 12 exercise sessions. The subjects were randomly allocated to 2 groups where 15 elders were allocated to PIP and the rest 15 elders were allocated to general exercise (GE) group. Fall efficacy scale (FES) and GAITRite were used for the measurements in this study. Paired t-test was used to analyze the differences within the

group while independent t-test was used to analyze the difference between two groups. In the comparison of measurements before and after exercise program, FES, velocity, cadence, and stride length were shown to be significantly increased in both PIP group and GE group. Also, in the comparison between two groups after the exercise program, the measurements of FES, cadence, stride length, and step length in PIP group were shown to be significantly increased compared to the GE group. Therefore, the PNF combined pattern is judged to be applicable to as methods for fall reoccurrence prevention and physical functions enhancement of the elders with experience of being fallen.

**Keywords:** Elders, Fall efficacy, Gait, Proprioceptive neuromuscular facilitation

## INTRODUCTION

According to the statistics on the elderly in 2010, Korea has already become an aging society as 11% of total population is elderly population due to the extended average life expectancy. Hence, the health of the elderly is receiving great importance, and especially the falls in the elderly is coming up as issues in health and medical issues. According to the Korea Centers for Disease Control and Prevention (2007), most of the patients who visited hospital emergency room because of slight injuries from fall are mainly 0 to 9 yr old while 63.6% of patients with severe injuries were elders above 70 yr old. 14.9% of the total elderly population in 2008 experienced fall down, and 17.2% of elders above 65 yr old

experienced fall down with average 2.2 times of fall which implies the existence of risk of reoccurrence. Falls in the elders are recognized as serious problem because the elders have difficulty in recovering from physical injuries or functional disabilities, and the elders often have severe complications which may lead to death (Rubenstein and Josephson, 2006). The physical and psychological aftereffects of falls more than falls itself are becoming the problems and these aftereffects were found in 3.2-32.6% of elders who experienced injuries from falls (Baranzini et al., 2009; Przybysz et al., 2008). These elders are restricted in daily life such as shopping and walking due to the fear for reoccurrence (Huang et al., 2003).

Decrease in general physical functions due to aging, weakening of body balance control ability, decline in gait ability, and fear for

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falls are the cause of falls in the elders (Murray et al., 2005). Disorder in gait and balance predicts falls better than other risk factors such as damaged vision and drug (Lamoth et al., 2011). The characteristics of gait in the elders are known to be decrease in stride length, increase in stride time, decrease in cadence, increase in walker use, and decrease in gait velocity (Kempen et al., 2007). Reduction of falls through improvement of body balance control ability, cardiovascular function and flexibility through regular exercise (Resnick, 2009) was shown to be effective strategy reducing the falls (Granacher et al., 2011).

In the precedent studies, elders performed various interventions including aerobic exercise (Aragão et al., 2011), resistance exercising using elastic band and muscular exercise using equipment (Persch et al., 2009), senior aerobic and taichi complex exercise (Trombetti et al., 2011) to enhance the physical functions. However, muscular exercise had weaknesses such as low interest and participation rate, due to repetition of simple motions, spatial restrictions, and requiring equipment and apparatus for exercise.

Proprioceptive neuromuscular facilitation (PNF) integration pattern stimulates the proprioceptor within the muscle and tendon to enhance the performance, muscle vitality, flexibility, and balance (Klein et al., 20002); it is generally effective in maximizing the reaction of exercise unit by increasing the coordination which reacts to the stimulations in muscular strength, flexibility, and myoneural system.

Therefore, this study aims to investigate the effect of exercise program using PNF integration pattern, which is effective in enhancing physical skills of the elders with experience of injuries from falls, on the fall efficacy and gait ability. This study also aims to investigate the applicability of this pattern as exercise program which prevents reoccurrence of falls and improves physical functions.

## MATERIALS AND METHODS

### Study subjects

This study was conducted on 30 elders, who experienced injuries from falls where among 50 elders registered in the Seniors Welfare Center located in Gwangju, 5 elders who did not experience injuries from falls during past year, 8 elders with dementia, and 4 elders who withdrew during the program were excluded from the study. The study was conducted for 3 sessions a week for 4 weeks totaling 12 sessions. The purpose and method of this study was well-explained to all subjects, and all subjects voluntarily agreed to participate in the study. Study subjects were ran-

domly allocated to standing for PNF integration pattern program group (PIP group) and standing for general exercise program group (GE group) *via* draw.

### Measurement of confidence against injuries from falls

In order to investigate the confidence against injuries from falls, fall efficacy scale (FES) was used. FES contains the fear of performing 10 activities required in the daily life and allows measuring the degree of self-confidence against the injuries from falls during the activity (Tinetti et al., 1990). FES consists of 10 questions and uses 10 point measure where minimum 1 point to maximum 10 point can be answered to each question. Higher point implies strong confidence that one will not get injured from falls. The scale showed confidence level of Cronbach's  $\alpha = 0.81$  when it was applied to Korean elders. The inspector had 1:1 meeting with subjects for filling out FES.

### Measurement of spatial and temporal gait ability

To measure the temporal and spatial variables of the subjects, this study used GAITRite (CIR Systems Inc., USA). GAITRite Gold, Version 3.2b (CIR system Inc.) was used to process the data. Gender, age, weight, height, and actual length of legs were measured in advance and input to the GAITRite program. The subject started walking from the place 2 m away from the starting point of electronic gait mat to the place 2 m away from the end point of the mat to reduce the effect of acceleration and deceleration (Webster et al., 2005). An experienced professional processed the measurement and the measurements were repeated for three times to get average values.

### PNF integration pattern exercise program

The program being used in this study consists of warm-up exercise, main exercise, and cool-down exercise. Each set of warm-up exercise and cool-down exercise consist of swinging legs and arms and stretching four limbs 20 times. The time required for this exercise was 10 min. The PNF integration pattern was repeated 10 times for 3 sets in supine position, long sitting position, and standing position. The time required for this exercise was 30 min where 5 min breaks were given in consideration for the physical conditions of the subjects.

All of the movements were educated and practiced in advance so that all subjects became proficient in it and were performed with music to induce interest during the exercise program and increase the participation rate.

## Data analysis

For data analysis, SPSS Ver. 17.0 for windows was used. Descriptive statistics was used to analyze the general characteristics of the subjects while Shapiro test was used to analyze the homogeneity of measurements. Paired t-test was used to analyze the difference within the group before and after exercise program while independent t-test was used to analyze the difference between groups. The level of statistical significance was set at  $\alpha = 0.05$ .

## RESULTS

### General characteristics

General characteristics of subjects in PIP group are 5 males and 10 females, average age of  $81.81 \pm 7.48$  yr, average height of  $158.00 \pm 5.19$  cm, and average weight of  $58.94 \pm 11.36$  kg while the general characteristics of subjects in GE group are 8 males and 7 females, average age of  $78.50 \pm 5.54$  yr, average height of  $160.07 \pm 7.14$  cm, and average weight of  $62.64 \pm 12.12$  kg. The test for homogeneity in the measurements in different factors before intervention did not show significant difference between PIP group and GE group (Table 1).

**Table 1.** General properties of measured variables in subject (n=30)

|                          | PIP group (n=15)          | GE group (n=15) | t      |
|--------------------------|---------------------------|-----------------|--------|
| FES (score)              | 81.40 (8.49) <sup>a</sup> | 82.73 (8.63)    | -0.426 |
| Temporal gait parameters |                           |                 |        |
| Velocity (cm/s)          | 57.49 (20.16)             | 60.61 (22.19)   | -0.403 |
| Cadence (steps/min)      | 112.23 (18.47)            | 114.72 (20.66)  | -0.348 |
| Spatial gait parameters  |                           |                 |        |
| Stride length (cm)       | 65.28 (9.85)              | 64.84 (11.33)   | 0.11   |
| Step length (cm)         | 30.41 (8.14)              | 32.50 (9.95)    | -0.29  |

<sup>a</sup>Means (SD). FES, fall efficacy scale; PIP, proprioceptive neuromuscular facilitation integration pattern program; GE, general exercise program.

**Table 2.** Comparison of measured variables in PIP group and GE group (n=30)

|                          | PIP group (n=15)           |               | t <sup>a)</sup> | GE group (n=15) |                | t <sup>a)</sup> | t <sup>b)</sup> |
|--------------------------|----------------------------|---------------|-----------------|-----------------|----------------|-----------------|-----------------|
|                          | Pre-test                   | Post-test     |                 | Pre-test        | Post-test      |                 |                 |
| FES (score)              | 81.40 (8.49) <sup>a)</sup> | 94.66 (6.18)  | -9.37***        | 82.73 (8.63)    | 89.67 (5.34)   | -5.06***        | 3.213**         |
| Temporal gait parameters |                            |               |                 |                 |                |                 |                 |
| Velocity (cm/s)          | 57.49 (20.16)              | 75.82 (10.29) | -5.84***        | 60.61 (22.19)   | 71.73 (14.75)  | -3.65**         | 1.65            |
| Cadence (steps/min)      | 112.23 (18.47)             | 92.49 (12.54) | 6.19***         | 114.72 (20.66)  | 105.20 (20.38) | 4.73***         | 2.71*           |
| Spatial gait parameters  |                            |               |                 |                 |                |                 |                 |
| Stride length (cm)       | 65.28 (9.85)               | 73.22 (3.84)  | -3.22**         | 64.84 (11.33)   | 69.67 (5.39)   | -2.33*          | 2.11*           |
| Step length (cm)         | 30.41 (8.14)               | 42.23 (4.01)  | -1.32           | 32.50 (9.95)    | 38.41 (5.64)   | -1.25           | 2.07*           |

<sup>a)</sup>Within group comparison. <sup>b)</sup>Between group comparison. <sup>c)</sup>Means (SD). \* $P < 0.05$ . \*\* $P < 0.01$ . \*\*\* $P < 0.001$ . FES, fall efficacy scale; PIP, proprioceptive neuromuscular facilitation integration pattern program; GE, general exercise program.

### Changes in confidence against injuries from falls

Both in PIP group and GE group, FES was significantly increased ( $P < 0.01$ ) (Table 2) and PIP group had statistically significant increase in the difference between two groups after intervention ( $P < 0.01$ ) (Table 2).

### Changes in temporal gait factors

In the difference between measurements before and after intervention, the velocity of the elders in PIP group ( $P < 0.01$ ) and GE group ( $P < 0.01$ ) showed statistically significant increase (Table 2), on the other hand the difference between two groups after intervention was not statistically significant. In the difference between measurements before and after intervention, the cadence of the elders in PIP group and GE group ( $P < 0.01$ ) showed statistically significant increase while PIP group showed statistically significant increase compared to GE group ( $P < 0.05$ ) (Table 2) in the analysis of difference in two groups after intervention.

### Changes in spatial gait factors

In the difference between measurements before and after intervention, stride length values in PIP group ( $P < 0.01$ ) and GE group ( $P < 0.05$ ) showed statistically significant increase and the PIP group showed statistically significant increase compared to GE group ( $P < 0.05$ ) (Table 2) in the analysis of difference in two groups after intervention. In the difference between measurements before and after intervention, difference in step length was not statistically significant in both PIP group and GE group (Table 2), while PIP group showed statistically significant increase compared to the GE group ( $P < 0.05$ ) (Table 2).

## DISCUSSION

This study aimed to investigate the effect of exercise program

using PNF integration pattern, which is effective in improving the physical functions of the elders who experienced injuries from falls, on the fall efficacy and gait ability and to investigate the applicability as exercise program for improvement in physical functions and prevention of reoccurrence of falls.

The balance control ability of elders are gradually decreased and probability of experiencing falls and frequency increase as the balance control ability is decreased (Denkinger et al., 2010). Rochat et al. (2010) showed that statistically significant difference in gait velocity, cadence, and fall efficacy of healthy elders without experience of injuries from falls over healthy elders with experience of injuries from falls. In other words, low efficacy in even subjects with good health has close relationship with decline in physical function and occurrence of injuries from falls in the future. Two groups had statistically significant increase before and after intervention and statistically significant difference between two groups after intervention. These results are identical to the research results of Hill et al. (2008) where 7.4 score on fall efficacy from 454 elders and similar improvements after intervention were reported. The integration pattern was performed in various positions and had increasing effect in the flexibility and balance control ability of the subjects.

Fifteen percent of elders above 60 yr old shows gait disorder and this gait disorder becomes the risk factor of injuries from falls. The gait velocity, step length, and cadence decrease which implies that human body gets adapted to use cautious gait pattern to increase the stability of gait and reduce the danger of injuries from falls (Lamoth et al., 2011; Mirelman et al., 2010). PNF integration pattern program of this study lets subjects maintain straight posture with erect trunk to induce posture arrangement to improve the degree of bent and creates more statistically significant difference compared to GE group.

The velocity did not have significant difference between two groups but velocity significantly increased when velocity before intervention and after intervention are compared. These results are identical to the research results of Trombetti et al. (2011) which reported that cadence did not have significant increase after exercise was given but gait velocity had significant increase, the increased effect in velocity was continued after 6 months, and 54% of subjects had reduced injuries from falls. Also the results were identical to the research results of Allet et al. (2010) which reported that gait velocity of elders with diabetes had 11.6% increase after exercising twice a week for 12 weeks which was statistically significant increase. Regular exercise imposed on the elders improves body balancing ability, flexibility, general cardiovascular

functions (Resnick, 2009) and effectively reduces the injuries from falls of elders (Granacher et al., 2011; Yeom et al., 2009). Especially, proprioceptive neuromuscular facilitation (PNF) uses the proprioceptive stimulating utilizing distinct helical form pattern to aid reaction of motor system located in muscles and joints, and turn human movements into patterns for various uses such as exercise intervention

This study confirmed that significant increase in fall efficacy, cadence, and stride length after exercise program composed based on this. The results of study suggested that this program is applicable as prevention movement program to prevent reoccurrence of injuries from falls of the elders with experience of injuries from falls. But the results of the study can't be generalized due to its small number of subjects and short period of intervention compared to precedent studies. Future studies must combine various factors such as motivation to continue the effects of program.

## CONFLICT OF INTEREST

There are no potential conflicts of interest relevant to this article.

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