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Original Article

Analysis of Core Stability Exercise Effect on the Physical and Psychological Function of Elderly Women Vulnerable to Falls during Obstacle Negotiation

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Abstract. [Purpose] The aim of the present study was to investigate the effects of core stability exercise (CSE) on the physical and psychological functions of elderly women while negotiating general obstacles. [Subjects and Methods] After allocating 10 elderly women each to the core stability training group and the control group, we carried out Performance-Oriented Mobility Assessment (POMA) and measured crossing velocity (CV), maximum vertical heel clearance (MVHC), and knee flexion angle for assessing physical performances. We evaluated depression and fear of falling for assessing psychological functions. [Results] Relative to the control group, the core stability training group showed statistically significant overall changes after the training session: an increase in POMA scores, faster CV, lower MVHC, and a decrease in knee flexion angle. Furthermore, depression and fear of falling decreased significantly. [Conclusion] CSE can have a positive effect on the improvement of physical and psychological performances of older women who are vulnerable to falls as they negotiate everyday obstacles.
Key words: Core stabilization exercises, Elderly women, Falls

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INTRODUCTION

Falls are one of the leading injury-related accidents involving older adults whose muscular strength, proprioceptive sense, and bodily coordination are compromised with aging[1)]. The elderly lack obstacle negotiation capacity and are prone to trip over commonly encountered environmental barriers such as door sills, pavement blocks, and safety bumps[2)]. In a local community, 33% of elderly people were reported to experience falls, of which 42.4% suffered falls[3)].

Individuals with a history of falls have fears of repeated falls, depression, and anxiety, all of which lead to decreased physical activities[4)]. These negative experiences result in reduced physical capacity in terms of muscular strength, bodily flexibility, and coordination, rendering the affected elderly even more susceptible to falls in a vicious cycle[5)]. Notably, elderly women are more at risk of secondary injury such as severe fractures after falling than elderly men because of their low bone density after menopause[6)].

Interventions for fall prevention include exercise, education, environmental improvements, and medication[7–9)], of which exercise has been used in fall prevention programs in many ways, as it takes less time and money to implement and programs are easy to set up.

Carter et al.[10)] reported in a bibliographical study on exercise intervention that exercise improved leg strength 44.4% and balance ability 37.5% in older adults and that as weakness of muscle strength in the trunk was more important than that in the lower extremities, strengthening of lumbar function can improve functional stability, leading to increased balance ability, gait ability, and prevention of falling[11, 12)].

Core stabilization exercise (CSE) can improve balance control ability by reinforcing intersegmental muscles in the multifidus, transversus abdominis, and rotators[13)] and physicopsychological functions in a harmonious way by stimulating proprioception powerfully when it is accompanied by Swiss ball exercises, improving balance sense, and maintenance ability[14)]. Previous studies on falling in elderly adults involving CSE have been limited to balance ability or gait ability[15, 16)], and there have been only a few studies on obstacles as an environmental factor or psychological factors.

Therefore, this study evaluated changes in the physicopsychological functions of elderly women with a fear of falling in negotiating obstacles such as a doorstep (5.2 cm) of a bathroom, where falling occurs frequently, through a Performance-Oriented Mobility Assessment (POMA) in

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order to understand whether CSE is valid as an efficient exercise to prevent and control falling in consideration of the physicopsychological functions of elderly women.

SUBJECTS AND METHODS

The subjects of the study were 20 elderly women above the age of 65 who were able to walk independently, did not have experience participating in regular balance training more than twice a week within the past 6 months, had a score higher than 24 on the Mini-Mental Status Examination-Korea (MMSE-K), had no limits on exercise performance due to visual or musculoskeletal disorders and no previous experience of falling, and scored lower than 19 on the Tinetti POMA[17]. The purpose and methods of this study were explained to all the participants, who read and signed an informed consent from that revealed all the details of the study protocol, which were approved by the ethics committee of Kangwon National University (No. 2013-11-001-002).

The subjects selected were divided into an experimental group and a control group by drawing lots, and the average age, height, and weight in the experimental group were 73.20±3.46 years, 152.15±4.29 cm, and 57.78±7.95 kg, while those in the control group were 71.00±3.50 years, 149.83±6.45 cm, and 53.80±11.04 kg. There were no significant differences among the groups with regard to age, height, or weight ($p>0.05$).

The core stabilization exercise program proposed by Jeffrey[18] and Hesari et al.[19] was applied to the experimental group and CSE was composed of three steps. Level 1 consisted of abdominal hollowing in a supine position, abdominal hollowing in a prone position, abdominal hollowing in a quadruped position, abdominal hollowing in a supine position while curling the feet, abdominal hollowing in a prone position while curling the feet, and modified side bridging. Level 2 consisted of bridging with abdominal hollowing, pelvic bridging, the dying bug with abdominal hollowing, and abdominal hollowing while seated on a Swiss Ball. Level 3 consisted of pelvic bridging with a Swiss ball, bird dog exercise, twists on a Swiss ball, and bird dog exercises on a Swiss ball. The experimental group performed a core stabilization program consisting of three levels for 30 min, three times per week on alternate days, for 6 weeks. This program consisted of three levels, and the subjects began at exercise level 1 and proceeded to the next level according to the protocol for the day. Level 1 included static holds in a stable environment, Level 2 included dynamic movements in a stable environment, and Level 3 included dynamic movements in an unstable environment, such as on a Swiss ball, and resisted dynamic movements in an unstable environment.

Before the program and 6 weeks after the program, the Tinetti POMA, crossing velocity (CV), maximum vertical heel clearance (MVHC) and knee flexion angle, which are related to physical functions, were measured, and with respect to psychological functions, depression and fear of falling were measured. The Tinetti POMA is an instrument used to decide the degree of fear of falling and balance and mobility in elderly adults consisting of items scored on a 3-point scale. The maximum score is 28, with 16 points for balance and 12 points for gait. If a subject scores below 19, fear of falling is high, and scores of 19 to 24 indicate an intermediate degree for fear of falling; scores of 25 to 28 indicate no fear of falling. For the crossing velocity (CV), the horizontal distance from the point at which the leading limb leaves the ground to the point at which the heel returns to the ground again is divided by the time taken[20]. For the maximum vertical heel clearance (MVHC), the vertical distance from the height of the obstacle before obstacle negotiation to the ball of the leading limb was measured[21]. For the knee flexion angle, the angles were measured at the MVHC[22]. The obstacle was 60 cm long, 10 cm wide, and 5.2 cm high. The subjects began their gait 5 m from the obstacle and continued on 3 m after obstacle negotiation. Obstacle gait variables were filmed with a camcorder and saved on a computer. CV and MVHC were measured with the use of Dartfish software (Dartfish, Fribourg, Switzerland)[23], and the results were output in a data table. To analyze depression, the CES-D (Center for Epidemiological Studies-Depression Scale) was used. It is scored on a 4-point scale (0–3), and includes a total of 20 questions. The higher the score, the higher the depression[24]. For fear of falling, the FOFQ (Fear of Falling Questionnaire) was used. It is scored on a 4-point scale (1–4) and includes a total of 11 questions. The higher the score, the higher the fear of falling[25].

For statistical analysis of the results, SPSS 18.0 was used. The Shapiro-Wilk test was performed as a test of normality. To explain the differences in measurement variables according to the measurement period between exercise groups, a 2-way ANOVA with repeated measure was used, and the level of statistical significance was $\alpha=0.05$.

RESULTS

Repeated measure ANOVA to analyze changes in the POMA, CV, MVHC, KF, depression, and FOF according to the measurement periods showed that there was a statistically significant difference in the interaction between time and the groups and that the changes in POMA, CV, MVHC, KF, depression, and FOF according to time differed ($p<0.001$) (Table 1).

DISCUSSION

Older adults have low balance and stability due to physiological and functional decreases that occur with ageing[26], and to compensate for balance and stability in gait, cadence and stride length decrease[27]. In the case of obstacle negotiation, when the leading foot encounters obstacles, the center of the body moves forward and fear of falling increases[28]. In this case, the MVHC, joint angle, and CV are important measures to assess the ability of elderly adults to safely cross obstacles during gait[5, 29, 30]. Although falling is not always accompanied by physical injury, fear of falling again can be used to predict falling in elderly adults[5]. Fear of falling leads to a decrease in activity and low self-esteem for independent behavior[4] and has direct negative effects

Table 1. Changes in physical and psychological function

Variables	Group	Before	After
POMA (score)	EG (n=10)	17.60±1.34	19.30±1.57**
	CG (n=10)	17.80±1.40	17.60±1.43
CV (m/sec)	EG (n=10)	1.56±0.21	1.60±0.21*
	CG (n=10)	1.56±0.10	1.55±0.09
MVHC (cm)	EG (n=10)	7.42±1.38	7.02±1.33*
	CG (n=10)	7.36±1.62	7.31±1.74
KF (angle)	EG (n=10)	111.00±3.16	108.60±4.06*
	CG (n=10)	110.80±3.77	110.30±3.16
Depression (score)	EG (n=10)	27.10±3.67	24.50±3.34**
	CG (n=10)	26.00±2.58	25.20±3.00
Fear of falling (score)	EG (n=10)	22.50±1.43	19.80±1.69*
	CG (n=10)	22.60±3.27	21.90±3.54

Mean±SD. EG, experimental group; CG, control group; POMA, Performance-Oriented Mobility Assessment; CV, crossing velocity; MVHC, maximum vertical heel clearance; KF, knee flexion. *p<0.05; **p<0.01

that result in decreased balance and gait disorder[31, 32].

CSE is training to improve the stability of the trunk by inducing a correcting reaction and an equilibrium reaction through balance training of the flexors and extensors, and as it has been judged to have an effect on physicopsychological functions in obstacle negotiation, a clinical study was conducted.

The results of the present study showed that the Tinetti POMA, CV, MVHC, and knee flexion angle were significantly improved. Esculier et al.[33] provided lumbar stability training through a Wii Fit program for Parkinson's patients for 6 weeks and administered the Tinetti POMA. They reported that the scores significantly increased from 24 points to 28. Chou et al.[20] reported that the CV was slow for elderly adults with lower balance ability. Weerdesteyn et al.[21] provided balance, gait, and coordination training for elderly adults and reported that foot clearance decreased, which matched with the results of the present study. Park and Lee[22] reported that the maximum knee flexion angle of normal adults with lumbar stability was significantly lower in comparison with that of elderly adults with lumbar instability, which partially matched with the results of the present study. The study by Lee et al.[34], who reported that a falling prevention program decreased the GDS (Geriatric Depression Scale) significantly, was in agreement with the study by Duque et al.[35], who reported that fear of falling by elderly adults who experienced falling significantly decreased as a result of balance training using a virtual reality system.

Such results indicate that stability of the trunk was secured, as CSE decreased the sway area of the center of mass. Through harmonious exercise of the limbs based on physical stability, the subjects could negotiate obstacles precisely and easily, had higher self-esteem and had less fear of falling and depression. It is suggested that the 6-week CSE decreased excessive obstacle gait with physical instability in elderly women and improved their physicopsychological functions involving obstacle gait.

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