The effects of nine-square exercise on balance and cognitive function in older women

ผลของการออกกำลังกายด้วยตารางเก้าช่องต่อการทรงตัวและพุทธิปัญญาในผู้สูงอายุเพศหญิง

Sasiwimon Wannapong[1], Saowanee Nakmareong[1], Surussawadi Bennett[1], Nomjit Nualnetr[1,2,3]*

ศศิวิมล วรรณพงษ์[1], เสาวนีย์ นาคมะเริง[1], สุรัสวดี เบนเน็ตต์[1], น้อมจิตต์ นวลเนตร์[1,2,3]*

[1]School of Physical Therapy, Faculty of Associated Medical Sciences, Khon Kaen University

[2]Research and Training Center for Enhancing Quality of Life of Working-Age People, Khon Kaen University

[3]North-Eastern Stroke Research Group, Khon Kaen University

[1]สาขาวิชากายภาพบำบัด คณะเทคนิคการแพทย์ มหาวิทยาลัยขอนแก่น

[2]ศูนย์วิจัยและฝึกอบรมเพื่อส่งเสริมคุณภาพชีวิตคนวัยแรงงาน มหาวิทยาลัยขอนแก่น

[3]กลุ่มวิจัยโรคหลอดเลือดสมอง ภาคตะวันออกเฉียงเหนือ คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น

ABSTRACT

Background: Postural instability and impaired cognitive function are significant problems in older people. Presently, “the nine-square exercise” is popular among community-dwellers in Thailand. However, evidence of the benefits of the nine-square exercise on balance and cognitive function in older persons remains unclear.

Objective: To evaluate the effects of the nine-square exercise on balance and cognitive function in older women.

Methods: Participants were older women living in two communities of Chaiyaphum Province. One community was randomized to an experimental group (n=17); the other was a control group (n=17). The experimental group practiced nine-square exercise for 30 minutes/day, three days/week for five weeks, while the control group attended health education classes twice. At baseline and the end of the study, all participants were evaluated for balance and cognitive function using the Timed Up and Go Test (TUGT) and the Montreal Cognitive Assessment, respectively. Independent and paired t-tests were used to examine differences between groups and within group, respectively. The statistically significant level was set at $p<0.05$.

Results: When compared pre- and post-study, the experimental group significantly improved balance and cognitive function ($p<0.05$). When compared between groups, the experimental group showed significantly less time taken to complete the TUGT than did the control group ($p<0.001$, mean difference -2.29 seconds, 95% CI -3.17 to -1.42 seconds). No statistically significant difference between groups was found in the cognitive function ($p=0.295$).

Conclusion: Nine-square exercise could improve balance in older women. Therefore, this exercise is possibly an alternative exercise regimen for improving balance in the elderly.

Keywords: Elderly, Exercise, Balance, Falls

บทคัดย่อ

ที่มาและความสำคัญ: ความไม่มั่นคงในการทรงตัวและความบกพร่องในการทำงานของสมองด้านพุทธิปัญญาเป็นปัญหาที่สำคัญของผู้สูงอายุ ปัจจุบันการออกกำลังกายด้วยตารางเก้าช่องเป็นที่แพร่หลายในชุมชนของประเทศไทย อย่างไรก็ตาม การศึกษาเกี่ยวกับ

*Corresponding author: Nomjit Nualnetr, School of Physical Therapy, Faculty of Associated Medical Sciences, Khon Kaen University, Khon Kaen, Thailand. E-mail: nomjit@kku.ac.th

Received: 08 Apr 2020; Revised: 13 May 2020; Accepted: 22 May 2020

ประโยชน์ของการออกกำลังกายด้วยตารางเก้าช่องต่อการทรงตัวและพุทธิปัญญาของผู้สูงอายุยังไม่ชัดเจน

วัตถุประสงค์: เพื่อศึกษาผลของการออกกำลังกายด้วยตารางเก้าช่องต่อการทรงตัวและพุทธิปัญญาในผู้สูงอายุเพศหญิง

วิธีการวิจัย: อาสาสมัครคือผู้สูงอายุเพศหญิงที่อาศัยใน 2 ชุมชนของจังหวัดชัยภูมิ โดยชุมชนหนึ่งถูกสุ่มเป็นกลุ่มทดลอง (จำนวน 17 คน) ส่วนอีกชุมชนหนึ่งเป็นกลุ่มควบคุม (จำนวน 17 คน) อาสาสมัครกลุ่มทดลองได้รับการฝึกออกกำลังกายด้วยตารางเก้าช่องวันละ 30 นาที จำนวน 3 วันต่อสัปดาห์ เป็นเวลา 5 สัปดาห์ ส่วนอาสาสมัครกลุ่มควบคุมได้รับการอบรมความรู้เป็นจำนวน 2 ครั้ง โดยก่อนและหลังการศึกษาอาสาสมัครทั้งหมดได้รับการประเมินการทรงตัวและพุทธิปัญญาด้วย Timed Up and Go Test (TUGT) และ Montreal Cognitive Assessment ตามลำดับ เปรียบเทียบความแตกต่างของตัวแปรก่อนและหลังเข้าร่วมการศึกษาระหว่างกลุ่มด้วยสถิติ independent t-test และภายในกลุ่มด้วยสถิติ paired t-test กำหนดค่านัยสำคัญทางสถิติที่ $p<0.05$

ผลการวิจัย: เมื่อเปรียบเทียบก่อนและหลังสิ้นสุดการศึกษา อาสาสมัครกลุ่มทดลองมีการทรงตัวและพุทธิปัญญาดีขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) และเมื่อเปรียบเทียบระหว่างกลุ่ม พบว่ากลุ่มทดลองใช้เวลาในการทดสอบ TUGT น้อยกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ ($p<0.001$, ความแตกต่างระหว่างกลุ่ม -2.29 วินาที, 95% CI -3.17 ถึง -1.42 วินาที) ส่วนตัวแปรด้านพุทธิปัญญาพบว่าทั้ง 2 กลุ่มมีความแตกต่างกันอย่างไม่มีนัยสำคัญทางสถิติ ($p=0.295$)

สรุปผล: การออกกำลังกายด้วยตารางเก้าช่องช่วยเพิ่มความสามารถในทรงตัวของผู้สูงอายุเพศหญิงได้ จึงอาจเป็นทางเลือกหนึ่งสำหรับการออกกำลังกายเพื่อพัฒนาการทรงตัวของผู้สูงอายุต่อไป

คำสำคัญ: ผู้สูงอายุ การออกกำลังกาย การทรงตัว หกล้ม

Introduction

The proportion of older people in Thailand is expected to increase from 17% in 2017 to 27% in 2030 and up to 32% in the next 30 years[1,2]. The elderly are more prone to diseases, syndromes, and poor health conditions than other age groups. The aging process can lead to significant physiological and pathological changes, which seem to be associated with an impairment of cognitive function and reductions in functional capacity components, e. g. , balance, muscle strength, and agility[3]. These deteriorations are frequently connected to increased risk for falls in older individuals[4]. In Thailand, the incidence of falls in the elderly is 23.2%[5]. This incidence is 1.5-2 times more frequent in women than in men[6,7].

In recent years, there has been wide acceptance of the benefits of exercise on balance and cognitive function in the elderly[8,9]. Exercise regimens recommended for balance improvement include changes in the center of mass, environment, and balance-related sensory inputs, decreases in a base of support and manual support, and increases in movement velocity, numbers of tasks, and balance conditions[10]. Exercises for improving cognitive function should be combined with physical exercises in the form of simultaneous or subsequent training[11]. Whatever the forms, however, the exercise programs for the elderly should be an enjoyable social activity, can be performed anywhere regardless of season or weather, and does not require special equipment. This will help promote

the engagement of older people in exercises[12]. A pleasurable and uncomplicated exercise, namely "the nine-square exercise", is becoming popular among Thai people. Based on a concept of "simple actions to achieve optimum benefits", this exercise was originated by Associate Professor Charoen Krabuanrat in 1996 in order to improve speed, coordination, balance, and agility in athletes[13]. Nevertheless, existing studies revealed beneficial effects of nine-square exercise on various aspects of health in young and older adults such as agility[14], reaction time[15], cardiopulmonary endurance[16], muscle strength[17,18], and mental stress[19]. Since movements in the nine-square exercise are in line with the principles of balance exercise, i. e. , changes in the center of mass and movement velocity[10], this exercise has been widely included in community-based health promotion programs to improve balance for Thai elderly. However, evidence of the benefit of the nine-square exercise on balance is still inconclusive. Cheunsakulpong and Abthaisong[20] reported that the nine-square exercise could improve balance and memory in patients with psychiatric conditions (age 55-75 years). However, there were no comparison groups in this report, and some of the participants were not the elderly. A recent study[17]demonstrated no significant difference in balance improvement between nine-square and conventional balance exercise programs in older women (age 70-79 years), possibly due to no risk for falls of the participants and too short period of the program.

Furthermore, the nine-square exercise can be classified as a simultaneously combined physical and cognitive training since individuals have to follow several step patterns which require physical exertion and a high level of cognitive function, specifically concentrated attention and memory. However, no study involving nine-square exercise and cognitive function in healthy older adults is available in the literature reviews. Therefore, it should be claimed that there is a paucity of scientific knowledge about the effectiveness of the nine-square exercise on balance and cognitive function in the elderly. As a result, a study is needed to evaluate how nine-square exercise affects the balance and cognitive function of older people. The current study aimed to evaluate the effects of nine-square exercise on balance and cognitive function in older women.

Methods

This study was an assessor-blinded experimental trial conducted from November 2018 to February 2019 in Kaengkhro District, Chaiyaphum Province. The research protocol was approved by the Khon Kaen University Ethics Committee for Human Research (HE612277) based on the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines and was registered at the Thai Clinical Trials Registry (TCTR20190521003). Written informed consent was required to proceed before the data collection.

Participants

Two communities of Kaengkhro District were randomly assigned to be either experimental

or control study areas. These communities were chosen due to the large numbers of older persons and the convenience of the principal investigator (Sasiwimon Wannapong) reaching the areas within half an hour. The process of participant recruitment was held at a community hall of each community. Older women of the communities were recruited through an advertisement asking for volunteers with the following inclusion criteria: age 60-79 years, body mass index (BMI) 18.5-29.9 kg/m^2, completing the Timed Up and Go Test (TUGT) with the time longer than 13.5 seconds (indicating older adults with risk for falls)[21], being able to communicate verbally and willing to participate and cooperate with the study procedures. Volunteers were excluded if a practitioner determined them that they had significant psychiatric or general medical morbidity precluding their understanding of the nature of the intervention or undertaking the exercises, had a severe cognitive problem (Mini-Mental State Examination in Thai version [MMSE-Thai] <23 for high school education and higher, <18 for elementary school education and <15 for unschooled or illiterate persons)[22], walked with gait aid and currently participated in other exercise programs or other research studies regarding balance and cognitive function. Furthermore, obese older women (BMI≥30.0 kg/m^2) were excluded to decrease emergency events during the study, e.g. falls. The participants were withdrawn from the study if they wanted and/or had to be hospitalized during the study period. The target sample size of 34 (17 per group) was calculated to ensure at least 80% power with 5% significance to detect changes in the TUGT and the Montreal Cognitive Assessment (MoCA) of 2.6±1.6 seconds[23] and 4.0±3.7 points[24], respectively. A maximum drop-out rate of 20% was assumed.

Interventions

The American College of Sports Medicine[25] has recommended that to improve balance effectively, the elderly should perform a balance exercise program 20-30 minutes/day, at least twice a week with a moderate to high intensity. Therefore, the participants in the experimental group were assigned to practice a group-based nine-square exercise program 30 minutes/day, three times/week for five weeks (15 exercise classes in total). This exercise program was classified as a dynamic exercise with moderate intensity (40-60% HRmax or the Borg Rating of Perceived Exertion [RPE] scale at 12-13)[26,27]. The program consisted of a five-minute warm-up, 20-minute nine-square exercise, and five-minute cool-down. In the nine-square exercise session, the participants were advised to step on the floor (90x90 centimeters), partitioned into nine squares. Four step patterns previously applied to Thai older women[17] were included, i.e., lateral, up and down, diamond, and cross steps (Figure 1). All exercise classes were accompanied by music to facilitate the enjoyment of the elderly. By increasing the music tempo, the movement velocity of the nine-square exercise was gradually made faster over the five weeks to ensure that all participants were able to practice all step patterns. The group-based exercise classes were held on Monday, Wednesday, and Friday at the

community hall under the direction of the principal investigator. Additional classes were arranged for the participants who could not attend on the scheduled dates. Thus, all participants in the experimental group completed a total of 15 exercise classes. Each exercise class was conducted for a maximum of nine participants to ensure optimal supervision by the investigator. Village health volunteers, who were trained for the nine-square exercise prior to commencing the study, also attended the exercise classes to provide help to individual participants and immediate assistance in an emergency. The ratio of village health volunteers to participants was 1:2. The participants were asked to stop exercising if they were unable to talk comfortably during exercise or the RPE>13[27,28]. The feasibility of implementing the nine-square exercise was assessed by recording adverse events, e.g. falls, extreme fatigue, throughout the study.

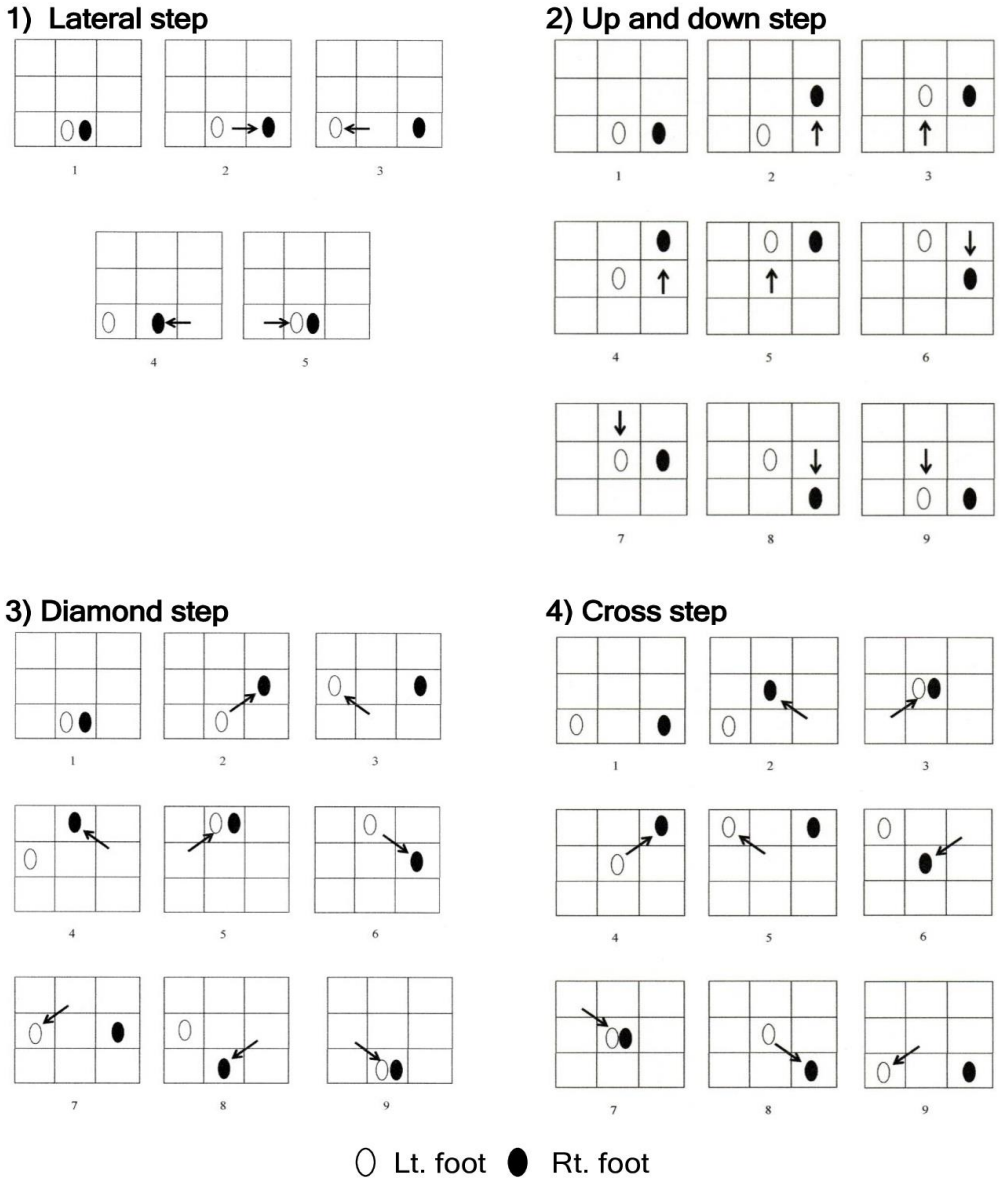

Figure 1 Step patterns of nine-square exercise

The participants in the control group attended 60-minute health education classes designed to reinforce the importance of participants maintaining their pre-program level of activity and to ensuring a minimal attrition rate. The classes were conducted by the principal investigator twice at the second and fourth weeks of the study period. The following topics of interest were presented: common health problems of the elderly, causes and prevention of falls, osteoarthritis, nutrition, and exercise for the elderly.

All participants were requested to maintain their pre-program level of exercise and continue their normal daily life activities throughout the study. They were asked to refrain from commencing any new physical activity program for the duration of the study.

Outcome measures

Balance is necessary for maintaining a position and remaining stable while moving from one position to another[29]. Therefore, to evaluate the balance performance of an individual effectively, balance measures should be focused not only on the ability of a person to maintain an upright stance, but also on their ability to adjust their posture to perform functional movements. These activities are included in the TUGT[30]. Furthermore, the measure of balance in the TUGT is not dependent on observer variability. The TUGT is able to detect a change in balance of the elderly following exercise programs[30,31]. This psychometric property is an important criterion for any balance test. Regarding cognitive function, the high standard assessment tools for detecting cognitive impairment are the Computerized Assessment Battery Test for cognitive function[32] and the Cambridge Brain Sciences computerized cognitive battery[33]. However, these objective assessment tools require training as well as technical support; the feasibility of these in the community setting is questionable. Therefore, this study evaluated the cognitive function using the MoCA in Thai version (MoCA-Thai)[22,34,35], a subjective assessment tool. The TUGT and the MoCA-Thai are appropriate for uses with older people because both measures are comprehensive, safe, quick and easy to administer, and not too complicated.

The TUGT and the MoCA-Thai of individual participants were assessed at pre- and post-intervention periods. All assessments were administered by a research assistant who was blind to the study group assignment. The time recorded for analysis of the TUGT was an average of the two trials, recorded to the nearest one-hundredth of a second. The participants were required to answer 10 sub-tests for the MoCA-Thai, including alternative trail making, visuoconstructional skill, naming, memory, attention, sentence repetition, verbal fluency, abstraction, delay recall, and orientation[34]. The score ranges from 0 to 30 points, with higher scores reflecting high ability in cognitive function. Pre- and post-intervention assessments were done within three days before commencing and after completing the intervention programs, respectively. On the assessment days, the participants were instructed to refrain from

drinking tea, coffee or Coca-Cola, and smoking for at least four hours prior to all testing sessions.

Statistical analysis

Descriptive analyses were generated to present the demographic characteristics of the participants. The normality of the data set was assessed using the Shapiro-Wilk test. An independent t-test was used to explore the effects of the nine-square exercise on balance and cognitive function of the experimental group when compared with the control group. A paired t-test was applied to compare outcome measures before and after both interventions. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 21.0. Statistical significance was set at *p*-value <0.05.

Results

Participants

A total of 53 volunteers of both study areas were screened as per the inclusion and exclusion criteria; out of which 34 (64.2%) were included (17 per group). All of them completed the study with no adverse events. Table 1 shows the demographic characteristics of the participants. Their average age was 63. 8±2. 0 years (range 61-69 years). About 94% of them had some non-communicable diseases such as diabetes, hypertension, and dyslipidemia.

Outcome measures

Results for comparisons of balance and cognitive function between the experimental and control groups are presented in Table 2. Baseline data of the tests did not significantly differ between groups. At the end of the study, only the experimental group showed significant improvements in the TUGT and the MoCA-Thai compared to before exercise. Comparisons between the study groups revealed that, after the five-week intervention programs, the time taken to complete the TUGT was significantly better in the experimental group than in the control group (p<0. 001). The mean difference in the TUGT between the experimental and control groups was 2.29 seconds (95% CI -3.17 to -1.42 seconds). No significant difference between groups was found in the MoCA-Thai (p=0.295).

Discussion

This study aimed to evaluate the effects of nine-square exercise, a dynamic exercise program with moderate intensity, on balance and cognitive function in community-dwelling older women. At the end of the study, it was revealed that when compared with baseline and with the control group, the nine-square exercise could significantly improve balance of the participants. This finding added to existing knowledge about the beneficial effect of exercise on balance in the elderly[36]. The movements of the nine-square exercise, which are in line with the principles of balance exercise, i.e., changes in the center of mass and movement velocity[10] may be the underlying explanation of balance improvement of the participants. The between-group significant difference in balance of older women in the current study contrasts with the finding obtained from a previous study[17]. A difference between the previous and current studies in intervention

Table 1 Demographic characteristics of the study population

Characteristics	Experimental group (n=17)	Control group (n=17)
Age (years) [mean (standard deviation)]	63.8 (1.9)	63.8 (2.2)
Body mass index (kg/m^2) [mean (standard deviation)]	23.6 (1.5)	23.9 (1.8)
Marital status [n (%)]		
- single	2 (11.8)	5 (29.4)
- married	13 (76.5)	10 (58.8)
- separated	2 (11.8)	2 (11.8)
Educational level [n (%)]		
- no formal education	0 (0.0)	1 (5.9)
- elementary school (primary or secondary)	14 (82.4)	16 (94.1)
- high school	3 (17.6)	0 (0.0)
Underlying medical conditions [n (%)]		
- yes (diabetes, hypertension, dyslipidemia)	16 (94.1)	16 (94.1)
- no	1 (5.9)	1 (5.9)
MMSE-Thai (0-30 points) [mean (standard deviation)]		
- overall	23.4 (2.2)	23.3 (2.2)
- no formal education	-	18.0 (0.0)
- elementary school (primary or secondary)	22.9 (2.2)	23.6 (1.8)
- high school	25.3 (0.6)	-

Note: MMSE-Thai: Mini-Mental State Examination in Thai version

programs for control groups (i.e., a conventional balance exercise program versus health education classes, respectively) may help to explain the inconsistent findings. Regarding a significant change in the time taken to complete the TUGT, it was observed that such a change did not reach a minimal detectable change (MDC) in the elderly of four seconds[37]. To reach the MDC of this balance test, future studies should increase the complexity of the nine-square step patterns and/or study period. Studies in the elderly with a higher risk for falls are also suggested.

Table 2 Outcome measures before and after interventions and comparisons between the study groups

Outcome measures	Experimental group (n=17)	Control group (n=17)	Between group differences (95% CI)	*p*-value*
Timed Up and Go Test (seconds)				
Pre-intervention	14.69 (0.76)	14.70 (1.03)	-0.01 (-0.64 to 0.62)	0.981
Post-intervention	11.99 (0.99)[a]	14.28 (1.47)	-2.29 (-3.17 to -1.42)	<0.001
Montreal Cognitive Assessment (0-30 points)				
Pre-intervention	25.53 (1.18)	25.35 (1.46)	0.18 (-0.75 to 1.10)	0.700
Post-intervention	26.06 (1.25)[a]	25.59 (1.33)	0.47 (-0.43 to 1.37)	0.295

Note: CI: confidence interval, Data expressed as mean (standard deviation), * Statistically significant difference between groups was defined as $p<0.05$, [a] Significant difference within group

The current study failed to show a significant effect of the nine-square exercise on the participants' cognitive function compared with the control group. This finding contrasts with the previous studies[38,39], which have revealed beneficial effects of simultaneously combined physical and cognitive exercise programs on cognitive function in the elderly. Possible explanations for the inconsistent findings are as follows. First, although the most effective exercise prescription for improving cognitive function is still inconclusive[40], it is noticeable that the study period of those previous studies[38,39] is longer than that of the current study (i.e., 16-24 weeks versus five weeks, respectively).Therefore, further studies with a longer study period are recommended to add evidence about the effectiveness of nine-square exercise on cognitive function in older individuals. Second, since both experimental and control groups were older women without cognitive impairment and already obtained high baseline scores of the MoCA-Thai (about 25 out of 30 points), opportunities for dramatic changes after the interventions might be small. This could lead to a non-significant finding between groups. Thus, future studies in older persons with some degrees of impaired cognition are suggested to broaden the beneficial impacts of nine-square exercise on cognitive function in the elderly. Third, the cognition mainly used during the nine-square exercise seems to be attention and memory, while the MoCA is a tool used to assess individuals' global cognitive status. Applications of more specific tests of attention and memory can detect changes in cognition resulting from the nine-square exercise; this claim should be explored in future studies.

Some study limitations were presented in the current study. First, despite attempting to recruit healthy older women aged 60-79 years, the study was limited to the young-old elderly (61-69 years old). Hence, the findings might not be extrapolated to other groups of the elderly. Second, since the participants were aware that they were taking part in a research study, part of changes in outcome measures observed in the study may be due to an increase in the participants' motivation. However, all participants were informed about the two interventions in the trial but were unaware of which intervention was hypothesized to be better. Furthermore, the research assistant who administered the outcome assessments was blinded to the group allocation, and a statistician who analyzed the outcome data was blinded to the treatment group assignment. Thus, although this was not a fully blinded study, measures were taken to minimize bias during data collection and analysis. Third, the exercise classes in this study were operated in groups under the supervision of the investigator. The generalization of the findings to other ways of the nine-square exercise is limited. Further studies of the effectiveness of nine-square exercise in the manner of individual or home-based exercise without leaders are recommended since these sorts of exercise probably affect the enjoyment and attendance at the exercise of the elderly, thereby reducing the positive effects of nine-square exercise. Fourth, to control for confounding in the study, the investigator asked all participants to maintain their pre-program level of daily activities throughout the study. However, to ensure this request, future studies should assign a diary to each participant for documenting her activities in daily life. Finally, due to time restraints, this study could only be carried out for five weeks. Thus, a longitudinal study is suggested to determine the long-term effects of the nine-square exercise. Additionally, since the nine-square exercise program in this study has been classified as a dynamic exercise with moderate intensity, further evaluations of the effects of such an exercise program on cardiorespiratory endurance are recommended.

Conclusion

When compared between groups, the superiority of the nine-square exercise over the health education in older women was presented in the balance performance but not in the cognitive function. No adverse conditions associated with the exercise were observed. Therefore, the nine-square exercise could be an alternative exercise regimen for improving balance in community-dwelling older women.

Acknowledgements

This study was supported by the Faculty of Associated Medical Sciences, Khon Kaen University. The most sincere thanks were expressed to all participants and staff of Chong Sam Mo and Na Nong Thum sub-district health promotion hospitals, Kaengkhro District, Chaiyaphum Province to cooperate with the study. Also, we would like to thank Miss Jittranon Wannapong for her help with statistical analysis.

References

1. Foundation for Older Persons' Development. Elderly situation in Thailand. Chiang Mai: Foundation for Older Persons' Development; 2015.
2. Mahidol Population Gazette. Thailand population 2017. Bangkok: Mahidol Population Gazette; 2017.
3. Bird ML, Pittaway JK, Cuisick I, Rattray M, Ahuja K. Age-related changes in physical fall risk factors: result from a 3 year follow-up of community dwelling older adults in Tasmania, Australia. Int J Environ Res Public Health. 2013; 10(11): 5989-97.
4. Dhargave P, Sendhilkumar R. Prevalence of risk factors for falls among elderly people living in long-term care homes. J Clin Gerontol Geriatr. 2016; 7(3): 99-103.
5. National Statistical Office Thailand. Working of the elderly in Thailand 2017. Bangkok: National Statistical Office Thailand, 2017.
6. Jitapunkul S, Na Songkhla M, Chayovan N, Chitratkul A, Choprapawon C, Kachondham Y, et al. Fall and their associated factor: a nation survey of the Thai elderly. J Med Assoc Thai. 1998; 81(4): 233-42.
7. Rongmuang D, Nakchattri C, Tongdee J, Sombutboon J. Incidence and factors associated with fall among the community-dwelling elderly, Suratthani. J Phrapokklao Nurs College. 2016; 27(Suppl1): 123-38.
8. Kamijo K, Hayashi Y, Sakai T, Yahiro T, Tanaka K, Nishihira Y. Acute effects of aerobic exercise on cognitive function in older adults. J Gerontol Psychol Sci. 2009; 64B(3): 356-63.
9. Kwon IH, Song JY, Kim DY, Son JY, Shim YJ, Shin WS. Comparison of rhythmic and non-rhythmic aerobic exercises on depression and balance in the elderly. Phys Ther Rehabil Sci. 2017; 6(3): 146-51.
10. Silsupadol P. Exercise as an intervention for preventing falls in community-dwelling older adults. Thai J Phys Ther. 2012; 34(3): 180-92.
11. Lauenroth A, Ioannidis AE, Teichmann B. Influence of combined physical and cognitive training on cognition: a systematic review. BMC Geriatr. 2016; 16(141): 1-14.
12. Yardley L, Beyer N, Hauer K, McKee K, Ballinger C, Todd C. Recommendations for promoting the engagement of older people in activities to prevent falls. Qual Saf Health Care. 2007; 16(3): 230-4.
13. Kerdjarean S. The effect of nine-square training on the table at the speed of 90 and 120 beats per minute upon the hand response time of 7-8 year-old boys [Master Thesis in Sports Science]. Bangkok: Graduate School, Kasetsart University, 2008.
14. Krabuanrat C, Manunyanon S. The effect of different size of the matrix of nine square on agility for badminton [Master Thesis in Sports Science]. Bangkok: Graduate School, Kasetsart University, 2011.
15. Watchiramekakul L, Krabuanrat C, Reungthai R. Effect of specific movement training program on reaction time in taekwondo player. J Sport Sci Tech. 2011; 11(1): 176-91.
16. Junprasert S, Toonsiri C, Chalaem T, Choojun N, Kirdnoil P, Songprasert A, et al. Impact of

nine-square Thai dancing on elderly people's health. Thai J Nurs Coun. 2013; 28(4): 60-80.

17. Nualnetr N, Aonsri C, Chaipipat N. A comparison of 9-square exercise and conventional balance exercise on balance in older women. Thai J Phys Ther. 2016; 38(3): 93-102.
18. Ronnarithivichai C, Thaweeboon T, Petchpansri S, Sujijantararat R, Boonchan N, Kridiborworn C. The evaluation of physical fitness before and after 9-square-table aerobic exercise and rubber ring stretching of elders in the health promotion program for the elderly, Faculty of Nursing, Mahidol University. J Nurs Sci. 2009; 27(3): 68-77.
19. Chidduan Y, Unaromlert T. Effects of stress reducing program to reduce the stress of children and youth in the Nakhonpathom Juvenile Detention Home. ASJ-PSU. 2013; 24(4): 65-78.
20. Cheunsakulpong T, Abthaisong O. The effect of moving the body in the nine squares table with balance and memory in geriatric psychiatric patients who admitted in Prakaisuk ward. J Srithanya Hospital. 2012; 13(1): 16-26.
21. Jalayondeja C. Falls screening by Timed Up and Go (TUG). J Med Tech Phys Ther. 2014; 26(1): 5-16.
22. Prasat Neurological Institute. Clinical practice guidelines: dementia. Bangkok: Tana Press Printing, 2014.
23. Nokham R, Panuthai S, Khampolsin T. Effect of square-stepping exercise on balance among older persons. Nurs J. 2016; 43(3): 58-68.
24. Joanne F, George SM, Claire O, Bellinda KK, Hilary C, Anne KR. Measurement error, reliability, and minimum detectable change in the Mini-Mental State Examination, Montreal Cognitive Assessment, and color trails test among community living middle-aged and older adults. J Alzheimers Dis. 2016; 53(3): 1107-14.
25. American College of Sports Medicine. ACSM issues new recommendations on quantity and quality of exercise [online] 2011 [cited 2018 February 28]. Available from: https://www.prweb.com/pdfdownload/8606343.pdf
26. Pescatello L, Arena R, Riebe D, Thompson P. ACSM's guidelines for exercise testing and prescription. 9th ed. Baltimore: Lippincott Williams & Wilkins, 2014.
27. Ritchie C. Rating of perceived exertion (RPE). J Physiother. 2012; 58(1): 62.
28. Anthony L, Aznar-Lain S. Intensity of physical activity and the "talk test": a brief review and practical application. ACSMs Health Fit J. 2008; 12(3): 13-7.
29. Berg KO, Maki BE, Williams JI, Holliday PJ, Wood-Dauphinee SL. Clinical and laboratory measures of postural balance in an elderly population. Arch Phys Med Rehabil. 1992; 73(11): 1073-80.
30. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991; 39(2): 142-8.
31. Skelton DA, McLaughlin AW. Training functional ability in old age. Physiotherapy 1996; 82(3): 159-67.

32. Nakayama Y, Covassin T, Schatz P, Nogle S, Kovan J. Examination of the test-retest reliability of a computerized neurocognitive test battery. Am J Sports Med. 2014; 42(8): 2000-5.
33. Boa Sorte Silva NC, Gill DP, Owen AM, Liu-Ambrose T, Hachinski V, Shigematsu R, et al. Cognitive changes following multiple modality exercise and mind-motor training in older adults with subjective cognitive complaints: The M4 study. Plos One. 2018; 13(4): e0196356.
34. Hemrungrojn S. Montreal cognitive assessment (MOCA) [online] 2011 [cited 2018 Jan 5]. Available from: http://mocatest.org/pdf_files/test/MoCA-Test-Thai.pdf
35. Tangwongchai S, Phanasathit M, Charernboon T, Akkayagorn L, Hemrungrojn S, Phanthumchinda K, Nasreddine ZS. The validity of Thai version of the Montreal Cognitive Assessment. Dement Neuropsychol. 2009; 3(2): 173.
36. Farlie MK, Molloy E, Keating JL, Haines PT. Clinical markers of the intensity of balance challenge: observational study of older adult responses to balance tasks. Phys Ther. 2016; 96(3): 313-23.
37. Mangione KK, Craik RL, McCormick AA, Blevins HL, White MB, Sullivan-Marx EM, et al. Detectable changes in physical performance measures in elderly African Americans. Phys Ther. 2010; 90(6): 921-7.
38. Kim SH, Kim M, Ahn YB, Lim HK, Kang SG, Cho JH, Park SJ, Song SW. Effect of dance exercise on cognitive function in elderly patients with metabolic syndrome: a pilot study. J Sports Sci Med. 2011; 10(4): 671-8.
39. Teixeira CVL, Gobbi S, Pereira JR, Ueno DT, Shigematsu R, Gobbi LTB. Effect of square-stepping exercise and basic exercises on functional fitness of older adults. Geriatr Gerontol Int. 2013; 13(4): 842-8.
40. Stroehlein JK, van den Bongard F, Barthel T, Reinsberger C. Dose-response relationship between physical activity and cognition in elderly. Dtsch Z Sportmed. 2017; 68(10): 234-42.