A Pilot Study of a 12-Week Leg Exercise and a 6- and 12-Month Follow-Up in Community-Dwelling Diabetic Elders: Effect on Dynamic Standing Balance

Vimonwan Hiengkaew PhD*,
Sasithorn Saengrueangrob MSc*, Kornkamon Cheawthamai MSc*

** Faculty of Physical Therapy, Mahidol University, Nakhon Pathom, Thailand*

Objective: *To determine the effects of 12-week leg exercise and follow-up on fasting blood glucose (FBG), blood pressure, static and dynamic standing balance time, leg muscle strength, and leg exercise behaviors in type 2 diabetic elderly.*
Material and Method: *Four females, completing 12-week leg exercise group and 6- and 12-month follow-up were examined for FBG, blood pressure, standing on firm and foam surfaces, single leg stance, Five-Times-Sit-to-Stand Test (FTSST), alternated stepping, and leg muscle strength at before leg exercise, week 12 of exercise, and months 6 and 12 follow-up after exercise. Friedman's ANOVA was used to compare these variables among 4 periods. Exercise behaviors were asked at months 6 and 12 follow-up.*
Results: *Significant decreased time was observed in FTSST between before and at week 12, and alternated stepping between before and at month 6. For one year follow-up, two participants performed leg exercise regularly. According to patients' interviews, they continued leg exercise because of reduced leg pain and stiffness, compliance to physiotherapist's suggestions, and exercise addiction.*
Conclusion: *Leg exercise enhanced FTSST and alternated stepping produced good quality feeling in leg in diabetic elderly. Physiotherapists may be a key for continuing leg exercise in community-dwelling diabetic elderly.*

Keywords: *Community, Diabetes mellitus, Elderly, Exercise, Lower limb*

J Med Assoc Thai 2015; 98 (Suppl. 5): S60-S67
Full text. e-Journal: *http://www.jmatonline.com*

Diabetic elderly have lower limb muscle weakness and postural instability. They showed muscle strength reduction in knee flexors and extensors, ankle plantar- and dorsi-flexors[1], in addition to foot intrinsic muscle weakness and foot deformity[2].They also demonstrated increased sway in anterior-posterior direction on unstable platform, increased time in Five-Times-Sit-to-Stand Test (FTSST) and Timed Up and Go Test, and decreased score in Berg Balance Scale[3]. Lower limb muscle weakness may contribute to postural instability. Effective strengthening exercise of knee extensors and flexors, and ankle plantar- and dorsi-flexors improves functional ability in community-dwelling balance-impaired elderly[4]. Thus, specific exercise may be useful to diabetic elderly.

Leg training twice weekly over 12 weeks improved dynamic balance and strength of hip flexors and ankle plantarflexors[5]. In addition, Tai Chi twice weekly for 12 weeks enhanced single leg stance, fasting blood glucose (FBG), and HbA1c[6]. However, leg training did not include foot muscle exercise. With long term regular exercise blood pressure is lowered in diabetic individuals[7]. However, previous studies showed no change in blood pressure after 3-month exercise[8,9]. Effect of long term regular exercise on blood pressure is still controversial. Additionally, exercise must be done consistently and depends on individual preference. Therefore, the present study designed leg exercise including foot muscles to apply among community-dwelling diabetic elderly, and determined its effect on FBG, blood pressure, standing balance, and leg muscle strength after 12-week exercise, 6- and 12-month follow-up. Furthermore, leg exercise behaviors during follow-up were investigated.

Correspondence to:
Hiengkaew V, Faculty of Physical Therapy, Mahidol University, 999 Phutthamonthon 4 Rd., Salaya, Nakhon Pathom 73170, Thailand.
Phone: +66-2-4415450, Fax: +66-2-4415454
E-mail: vimonwan.hie@mahidol.ac.th

Material and Method

Participants

Seventeen elders (4 males, 13 females) with a diagnosis of type 2 diabetes mellitus aged >60 years living in Thung Kraphang Hom Subdistrict, Kamphaengsaen District, Nakhon Pathom volunteered to participate in the study. The inclusion criteria were 1) verbal comprehension, 2) resting systolic blood pressure lower than 160 mmHg and diastolic blood pressure lower than 100 mmHg, 3) 90-100 points in Barthel Index, 4) no plantar skin ulcer, 5) no neurological and musculoskeletal system disorders and surgery, 6) no history of angina or angina equivalent symptoms, 7) no absolute exercise contraindications[10], 8) no blindness, 9) no history of falls during the past 12 months, and 10) walking independently without people or device assistance.

A flowchart of participants is shown in Fig. 1. Fourteen elderly (4 males, 10 females) qualified for the study. Eventually, 4 female participants completed the study (Table 1).

Study design

One group pretest and posttest and one year follow-up design was used (Fig. 1). The Mahidol University Institutional Review Board approved this study (MU-IRB COA. NO. 2013/046.1705). Participants were asked to read and sign consent forms before participating.

Participants were examined for FBG, blood pressure, static and dynamic standing balance, and lower limb muscle strength. FBG was performed on the tip of the left ring finger by glucose meter (Accu-Chek Performa Meter with strips). Blood pressure was determined by automatic blood pressure monitor (Omron, model: HEM-7200). Static balances examination included standing on firm and foam surfaces with eyes open and closed, in addition to one leg stance on dominance and nondominance. Dynamic balance was assessed by FTSST and alternated stepping on 19-cm high step as fast as possible 8 times by timing in second (s) (Casio, Tokyo, Japan). Lower limb muscle strength was assessed on the right and left leg by means of manual muscle testing[11] in hip flexors, knee flexors and extensors, ankle plantar- and dorsi- flexors, hallux metatarsophalangeal flexors and extensors, toe metatarsophalangeal flexors and extensors, hallux interphalangeal flexors and toe proximal and distal interphalangeal flexors. The inter- and intra-rater reliability was tested for the 10 muscles. The inter-rater reliability had an $ICC_{3,1}$ of 0.416-0.874, and the intra-rater had an $ICC_{1,1}$ of 0.682-0.873.

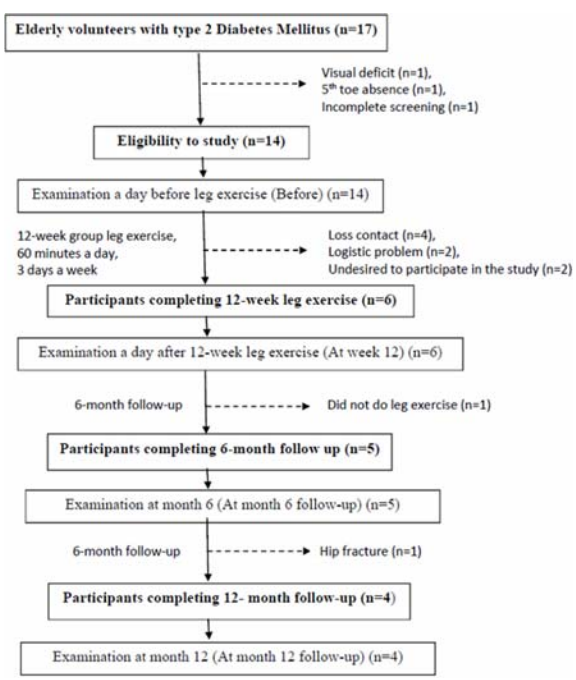

Fig. 1 Flow diagram of the study and participants.

All examinations were performed one day before leg exercise (before), one day after the last time of 12-week leg exercise (at week 12), and at months 6 and 12 after finishing the 12-week exercise (Fig. 1). In addition, at months 6 and 12 after 12-week exercise, participants were asked about leg exercise frequency and consistency, leg exercise motivation, and other exercises. Exercise behaviors at months 6 and 12 follow-up were described.

The leg exercise program consisted of 10-minute warm-up, 40-minute leg exercise, and 10-minute cool-down. Warm-up and cool-down consisted of right and left hip flexor stretching, knee flexor and ankle plantarflexor stretching, toes up and down, and turning ankle to the right and left. Stretching of hip and knee flexors and ankle plantarflexors was held for 15 seconds/ time for 5 times. Movement of toes and ankles was 10 times/direction. Leg exercise was composed of right and left foot grasping and releasing an object (foot grasping, hip flexion with dorsiflexed ankle, moving leg to the side, placing foot on floor, then releasing an object), semi-squatting, and alternated standing on heels and toes. Each exercise was performed 10 times/ set for 3 sets. Leg exercise was performed with eyes open and closed, except right and left foot grasping and releasing an object with only eyes open. Participants underwent leg exercises, 60 minutes each day, three nonconsecutive days weekly for 12 weeks under supervision of a researcher (SS). After finishing 12-week leg exercise, participants continued the exercise by themselves 60 minutes each day, three

Table 1. Characteristics of participants

Characteristics	Total (n = 14)		Participants (n = 4)	
	Mean ± SD (min-max)	n (%)	Mean ± SD (min-max)	n (%)
Age (years)	67.9±6.86 (60.0-79.0)		69.3±7.41 (61.0-76.0)	
Weight (kg)	61.5±10.49 (48.0-87.3)		61.1±9.14 (48.0-69.2)	
Height (cm)	156.8±7.19 (144.7-170.0)		153.5±2.33 (151.2-156.2)	
Body mass index(kg/m^2)	25.0±3.81 (18.1-31.7)		25.9±3.67 (20.8-28.9)	
Barthel index score (points)	100±0 (100.0-100.0)		100±0 (100-100)	
Duration of type 2 Diabetes Mellitus (years)	6.52±7.45 (0.25-25)		8.06±9.02 (0.25-20)	
Occupation				
Farmer		5 (35.7)		2 (50.0)
Housewife		5 (35.7)		2 (50.0)
Government service		2 (14.3)		
Worker		1 (7.14)		
None		1 (7.14)		
Treatment				
Medication		7 (50.0)		2 (50.0)
Medication and diet		4 (28.6)		1 (25.0)
None		3 (21.4)		1 (25.0)
Underlying diseases				
Hypertension alone		6 (42.9)		1 (25.0)
Heart disease alone		1 (7.14)		
Hypertension with other diseases				
Dyslipidemia		4 (28.6)		1 (25.0)
Osteoarthritis knee		1 (7.14)		1 (25.0)
Peptic ulcer and Pyelonephritis		1 (7.14)		
Heart disease and Dyslipidemia		1 (7.14)		1 (25.0)
History of surgery				
None		11 (78.6)		1 (25.0)
Balloon angioplasty		1 (7.14)		1 (25.0)
Hysterectomy		1 (7.14)		1 (25.0)
Caesarean section		1 (7.14)		1 (25.0)
Numbness				
None		7 (50.0)		2 (50.0)
Both hands		2 (14.3)		1 (25.0)
Hands and feet		4 (28.6)		1 (25.0)
Both feet		1 (7.14)		
Smoking				
None		10 (71.4)		4 (100.0)
Used to smoke		2 (14.3)		
Smoke		2 (14.3)		
Alcohol				
None		7 (50.0)		3 (75.0)
Used to drink		3 (21.4)		1 (25.0)
Drink		4 (28.6)		

Table 1. cont.

Characteristics	Total (n = 14)		Participants (n = 4)	
	Mean ± SD (min-max)	n (%)	Mean ± SD (min-max)	n (%)
Exercise/physical activity/hobby				
General exercise		2 (14.3)		1 (25.0)
Housework		4 (28.6)		1 (25.0)
Childhood care		1 (7.14)		1 (25.0)
Gardening		1 (7.14)		
Housework and childhood care		3 (21.4)		
Housework and gardening		2 (14.3)		
No answer		1 (7.14)		
Exercise behavior				
None		3 (21.4)		2 (50.0)
<2 days per week		7 (50.0)		2 (50.0)
2-3 days per week		3 (21.4)		
No answer		1 (7.14)		
Eating behavior				
2 meals a day and no snack		2 (14.3)		
3 meals a day + 1 snack break a day		5 (35.7)		
3 meals a day + 2 snack breaks a day		4 (28.6)		3 (75.0)
3 meals a day + 3 snack brakes a day		2 (14.3)		1 (25.0)
No answer		1 (7.14)		

nonconsecutive days weekly for one year. Participants received an exercise book consisting of leg exercise, exercise schedule, and record form.

Statistical analysis

Friedman's ANOVA in SPSS software version 15.0 was used to compare FBG, blood pressure, time in standing on firm and foam surfaces with eyes open and closed, one leg stance on dominance and nondominance, FTSST, and alternated stepping, and leg muscle strength at before, week 12, month 6 and 12-month follow-up. A *p*-value less than 0.05 was considered significant. When a significance was found, pairwise comparisons calculated the difference between the mean ranks of the difference periods ($|\bar{R}u - \bar{R}v|$) and compared these differences to critical difference ($Z_{a/k\,(k-1)}\sqrt{\frac{k\,(k+1)}{6N}}$), as shown in the equation[12] below. If the difference between mean ranks was greater than or equal to the critical difference, then that difference was considered significant.

$$|\bar{R}u - \bar{R}v| \text{ is more than } Z_{a/k\,(k-1)}\sqrt{\frac{k\,(k+1)}{6N}}$$

where: a (level of significance) = 0.05
k (number of conditions) = 4
N (sample size) = 4

thus; $|\bar{R}u - \bar{R}v|$ was more than 2.40997

Results

Significant change at before, week 12 and 6- and 12-month follow-up was observed in FTSST ($\chi^2_{(2)} = 9.300$, $p = 0.012$), alternated stepping ($\chi^2_{(2)} = 11.100$, $p = 0.001$), right hip flexors ($\chi^2_{(2)} = 10.200$, $p = 0.014$), and right ankle dorsiflexors ($\chi^2_{(2)} = 8.571$, $p = 0.042$). Pairwise comparison between periods of leg exercise showed significance in FTSST and alternated stepping only. A significant decrease was observed in FTSST time between before and at week 12, and alternated stepping time between before and at month 6 follow-up (Table 2). No difference was found in lower limb muscle strength between any periods except right hip flexor and ankle dorsiflexor muscles. Leg exercise behaviors at months 6 and 12 follow-up are described in Table 3.

Discussion

Leg exercise among diabetic elderly improved FTSST after 12-week exercise and enhanced alternated stepping at 6-month follow-up compared with before exercise. During one-year follow-up, two diabetic elderly frequently did leg exercise individually.

In the present study, leg exercise trained hip, knee, ankle and foot muscles. It decreased time in

Table 2. Mean ± SD of variables among before, at week 12, at months 6 and 12 after finishing a 12-week leg exercise in diabetic elderly (n = 4)

Variables	Leg exercise		Follow-up after finishing exercise	
	Before	At week 12	At month 6	At month 12
Fasting blood glucose (mg/dl)	157.0±47.8	116.3±33.0	154.3±59.3	149.5±36.6
Blood pressure (mmHg)				
Systolic	134.8±17.5	139.3±16.1	141.5±19.0	135.0±16.9
Diastolic	75.0±11.9	71.5±11.9	68.0±10.6	70.8±14.2
Standing on firm surface (s)				
Eyes open	30.0+0.00	30.0±0.00	30.0±0.00	30.0±0.00
Eyes closed	30.0±0.00	30.0±0.00	30.0±0.00	30.0±0.00
Standing on foam (s)				
Eyes open	30.0±0.00	30.0±0.00	30.0±0.00	30.0±0.00
Eyes closed	25.1±9.78	29.0±2.28	27.1±6.59	24.9±11.4
One leg stance (s)				
Dominant leg	10.7±10.9	12.9±11.7	20.4±11.7	15.3±10.9
Nondominant leg	14.3±12.0	20.2±11.9	12.0±12.1	16.9±15.2
Five times sit-to-stand (s)	12.8±5.77	7.43±1.58*	7.42±1.03	8.11±1.72
Alternated stepping (s)	11.6±3.81	7.31±1.04	6.87±0.86*	7.56±1.02

* Significant difference from before leg exercise

Table 3. Leg exercise behaviors at 6- and 12-month after 12-week leg exercise in diabetic elderly (n = 4)

	At month 6 follow-up	At month 12 follow-up
Regular leg exercise, n (%) and frequency		
Yes	1 (25%), 3-4 times/week	2 (50%), 3-7 times/week
No	3 (75%), 0-3 times/week	2 (50%), 1 time/week
Reason to do leg exercise		
Regularly	Feeling strong, recalling speech of physiotherapist when it timed to exercise, being instructed to do leg exercise.	Being instructed to do leg exercise, Feeling do nothing if do not do leg exercise.
Irregularly	Doing leg exercise when feeling leg weakness, numbness, instability, and stiffness. Spending time to look after grandchildren.	Doing leg exercise when needing more leg flexibility and reducing leg pain and stiffness.
Other exercises , n (%) and frequency		
Yes	2 (50%), Stick exercise 3-4 times/week and 100-step walking 7 times/week	3 (75%), Arm and/or leg swing, 1-7 times/week
No	2 (50%)	1 (25%)

FTSST and alternated stepping which are dynamic standing balances. Time in FTSST at 12-week leg exercise of the present study was less than that among Japanese women without history of falling[13], and time in alternated stepping at 6-month follow-up was less than that of elderly aged 75-90 years and over but similar to those aged 20-39 years[14]. This may have resulted from muscle practice in the leg exercise program. No improvement in static standing balance was observed. Ceiling effect of standing on a firm surface with eyes open and closed and on foam with eyes open was detected in our participants. In addition, a rather high performance was detected in standing on foam with eyes closed and standing on one leg on dominance and nondominance. Time in single leg stance before leg exercise in the present study was similar to several previous studies among the elderly[15-17]. Therefore, leg exercise seemed to enhance dynamic standing balance in our participants.

Although exercise in diabetic individuals reduced FBG[6,18,19] and blood pressure[7], leg exercise demonstrated no change in FBG and blood pressure. Similarly, no change was reported in blood pressure in diabetic individuals with exercise[8,9,18]. The difference may have resulted from exercise intensity and frequency. Leg exercise is of moderate intensity[20], whereas exercise in a previous study[19] was moderate to high intensity. Furthermore, exercise frequency in the present study was low during the follow-up period. Therefore, no change in FBG and blood pressure in diabetes elders with leg exercise was observed.

For one year follow-up, two of four participants regularly performed leg exercise because of being instructed to exercise, feeling good for health, and appearing addicted to leg exercise. However, three of four participants sometimes performed leg exercise because of feeling its specific effect, for instance, pain and stiffness reduction. It showed that diabetic elderly experienced benefits of leg exercise. However, all participants did not often perform leg exercise. Therefore, performing leg exercise or a specific exercise individually may need facilitation from health professions.

Right hip flexors and ankle dorsiflexor revealed significant differences among study periods. Exercise of foot grasping and releasing an object in the present study may have enhanced these two muscles. Hip flexion with dorsiflexed ankle was needed while performing that exercise. Nonetheless, no pair differences were found, probably due to the small sample size.

The present study had limitations. Despite the suggestion to examine the HbA1c for accumulative blood glucose control, the HbA1c could not be measured due to the lack of a field laboratory. Another limitation was the high dropout rate (70%). However, the sample size calculated pair difference for right hip flexors and ankle dorsiflexors required at least 8 and 43 participants at the most.

Conclusion

Community-dwelling diabetic elderly are suggested to perform leg exercise programs to improve dynamic standing balance that may affect activities of daily living, for example, sit-to-stand and stairs step-up. Leg exercise programs improved FTSST and alternated stepping performance in community-dwelling diabetic elderly, and resulted in pain and stiffness reduction as some of them reported. Since fewer diabetic elderly performed leg exercise regularly, it is suggested to motivate them. A larger sample size is suggested in future studies to investigate of the effect of exercise programs for leg muscle strength.

What is already known on this topic?

Diabetic elderly have weak muscles and postural balance. Specific exercises to improve leg muscle strength and functional balance are needed. However, foot muscle exercise was not involved in those exercises and continuation of exercise was not studied.

What this study adds?

The present leg exercise program includes a specific exercise for the foot muscle. It enhances dynamic standing balance among community-dwelling diabetic elderly. Long term regular leg exercise leads to decreased leg pain and stiffness in diabetic elderly.

Acknowledgement

Grateful thanks are given to the chief executive, health and general officials, and senior club of Thung Kraphang Hom Subdistrict, Kamphaeng Saen District, Nakhon Pathom, Thailand.

Potential conflicts of interest

None.

References

1. Andersen H, Nielsen S, Mogensen CE, Jakobsen J. Muscle strength in type 2 diabetes. Diabetes 2004; 53: 1543-8.

2. van Schie CH, Vermigli C, Carrington AL, Boulton A. Muscle weakness and foot deformities in diabetes: relationship to neuropathy and foot ulceration in caucasian diabetic men. Diabetes Care 2004; 27: 1668-73.
3. Vaz MM, Costa GC, Reis JG, Junior WM, Albuquerque de Paula FJ, Abreu DC. Postural control and functional strength in patients with type 2 diabetes mellitus with and without peripheral neuropathy. Arch Phys Med Rehabil 2013; 94: 2465-70.
4. Hess JA, Woollacott M. Effect of high-intensity strength-training on functional measures of balance ability in balance-impaired older adults. J Manipulative Physiol Ther 2005; 28: 582-90.
5. Allet L, Armand S, de Bie RA, Golay A, Monnin D, Aminian K, et al. The gait and balance of patients with diabetes can be improved: a randomised controlled trial. Diabetologia 2010; 53: 458-66.
6. Ahn S, Song R. Effects of Tai Chi Exercise on glucose control, neuropathy scores, balance, and quality of life in patients with type 2 diabetes and neuropathy. J Altern Complement Med 2012; 18: 1172-8.
7. Mobasseri M, Yavari A, Najafipoor F, Aliasgarzadeh A, Niafar M. Effect of a long-term regular physical activity on hypertension and body mass index in type 2 diabetes patients. J Sports Med Phys Fitness 2015; 55: 84-90.
8. Eriksson J, Taimela S, Eriksson K, Parviainen S, Peltonen J, Kujala U. Resistance training in the treatment of non-insulin-dependent diabetes mellitus. Int J Sports Med 1997; 18: 242-6.
9. Dunstan DW, Daly RM, Owen N, Jolley D, De Court, Shaw J, et al. High-intensity resistance training improves glycemic control in older patients with type 2 diabetes. Diabetes Care 2002; 25: 1729-36.
10. American College of Sports Medicine. ACSM's guidelines for exercise testing and prescription. 8th ed. Philadelphia: Wolters Kluwer Health/ Lippincott Williams & Wilkins; 2010.
11. Hislop HJ, Avers D, Brown M. Daniels and Worthingham's muscle testing: techniques of manual examination. 9th ed. St. Louis, Missouri: Saunder Elsevier; 2014.
12. Field A. Discovering statistics using SPSS. 2nd ed. London: SAGE Publications; 2005.
13. Morita M, Takamura N, Kusano Y, Abe Y, Moji K, Takemoto T, et al. Relationship between falls and physical performance measures among community-dwelling elderly women in Japan. Aging Clin Exp Res 2005; 17: 211-6.
14. Butler AA, Menant JC, Tiedemann AC, Lord SR. Age and gender differences in seven tests of functional mobility. J Neuroeng Rehabil 2009; 6: 31.
15. Lin MR, Hwang HF, Hu MH, Wu HD, Wang YW, Huang FC. Psychometric comparisons of the timed up and go, one-leg stand, functional reach, and Tinetti balance measures in community-dwelling older people. J Am Geriatr Soc 2004; 52: 1343-8.
16. Tsang T, Orr R, Lam P, Comino EJ, Singh MF. Health benefits of Tai Chi for older patients with type 2 diabetes: the "Move It For Diabetes study"-a randomized controlled trial. Clin Interv Aging 2007; 2: 429-39.
17. Nagai K, Inoue T, Yamada Y, Tateuchi H, Ikezoe T, Ichihashi N, et al. Effects of toe and ankle training in older people: a cross-over study. Geriatr Gerontol Int 2011; 11: 246-55.
18. Goldhaber-Fiebert JD, Goldhaber-Fiebert SN, Tristan ML, Nathan DM. Randomized controlled community-based nutrition and exercise intervention improves glycemia and cardiovascular risk factors in type 2 diabetic patients in rural Costa Rica. Diabetes Care 2003; 26: 24-9.
19. Misra A, Alappan NK, Vikram NK, Goel K, Gupta N, Mittal K, et al. Effect of supervised progressive resistance-exercise training protocol on insulin sensitivity, glycemia, lipids, and body composition in Asian Indians with type 2 diabetes. Diabetes Care 2008; 31: 1282-7.
20. US. Department of Health and Human Services. 2008 Physical activity guidelines for Americans. Be active, healthy, and happy! [Internet] 2008 [updated 2013; cited 2014 Nov 22]. Available from: http://www.health.gov/paguidelines/pdf/paguide.pdf

การศึกษานำร่องของการออกกำลังกายขา 12 สัปดาห์ และติดตาม 6 และ 12 เดือน ในผู้สูงอายุเบาหวานอาศัยในชุมชน: ผลต่อการทรงตัวเคลื่อนไหว

วิมลวรรณ เหียงแก้ว, ศศิธร แสงเรืองรอบ, กรกมล เจียวท่าไม้

วัตถุประสงค์: *ศึกษาผลของการออกกำลังกาย 12 สัปดาห์ และติดตามต่อน้ำตาลในเลือดหลังอดอาหาร (FBG) ความดันโลหิตเวลาทรงตัวนิ่งและเคลื่อนไหว ความแข็งแรงกล้ามเนื้อขา และพฤติกรรมออกกำลังกายขาในผู้สูงอายุเบาหวานชนิด 2*

วัสดุและวิธีการ: *ผู้หญิง 4 คน เสร็จสิ้นออกกำลังกายขาแบบกลุ่ม 12 สัปดาห์ และติดตาม 6 และ 12 เดือน ตรวจ FBG ความดันโลหิต การยืนนิ่งบนพื้นแข็งและนุ่ม ยืนขาเดียว ลุกยืนลงนั่ง 5 ครั้ง (FTSST) การก้าวสลับและความแข็งแรงกล้ามเนื้อขาที่ก่อนออกกำลังกายสัปดาห์ 12 ของการออกกำลังกาย เดือน 6 และ 12 หลัง ออกกำลังกาย Friedman เปรียบเทียบตัวแปรท่ามกลาง 4 เวลา พฤติกรรมออกกำลังกายถูกถามในเดือน 6 และ 12*

ผลการศึกษา: *เวลา FTSST ระหว่างก่อนและที่สัปดาห์ 12 และการก้าวสลับระหว่างก่อนและที่เดือน 6 ลดลงอย่างมีนัยสำคัญทางสถิติ สำหรับการติดตาม 1 ปี ผู้ร่วมวิจัย 2 คนออกกำลังกายขาสม่ำเสมอ เขาออกกำลังกายขาต่อเนื่องเพราะปวดขาและขาแข็งลดลง นักกายภาพบำบัดบอกให้ทำ และติดการออกกำลังกายขา*

สรุป: *การออกกำลังกายขาส่งเสริม FTSST และการก้าวสลับ และรู้สึกดีที่ขาด้วยในผู้สูงอายุเบาหวาน นักกายภาพบำบัดอาจเป็นกุญแจสำหรับความต่อเนื่องการออกกำลังกายขาในผู้สูงอายุเบาหวานอาศัยในชุมชน*