Effects of 8-Week Buerger's Exercise on Ankle-Brachial Index (ABI) and Leg Microcirculation in Type 2 Diabetes

Kanokporn Pakdeesang[1] Nantinee Nualnim[2] Vijj Kasemsup[3]
Kannika Permpoonputtana[4] Peeradech Thichanpiang[5]

Abstract

Type 2 diabetes mellitus (T2DM) is the third leading cause of death in Thailand. T2DM could develop its complication especially peripheral arterial disease (PAD) and could end up with foot ulceration or amputation affecting a huge impact on the quality of life. Aerobic exercise is typically recommended in T2DM. However, there are many barriers to restrict from participation in aerobic exercise program. Buerger's exercise was originally used as the treatment for Thromboangiitis Obliterans (TAO) by enhancing leg blood flow, so this exercise should be applied in T2DM. However, it lacks of evidence to investigate the effects of Buerger's exercise insight into prevention of DM complication. Our study aims to determine the responses of Buerger's exercise on ankle-brachial index (ABI) and leg microcirculation immediately post-exercise and 8-week exercise program. We hypothesized that Buerger's exercise could enhance leg microcirculation and change ABI from baseline. *Methods:* Ten participants (2 males and 8 females), the mean age of 55±7 years, were assigned to 8-week of Buerger's exercise. ABI and leg microcirculation were measured at baseline, post-exercise immediately, and after 8-week program. Results: Immediately after Buerger's exercise, the leg microcirculation in perfusion unit (PU) was increased from 14.8±7.4 to 26.2±8.6 ($p<0.05$). The ABI did not significantly change in any sessions. *Conclusion:* No significantly change of ABI and leg microcirculation after 8-week Buerger's exercise. However, this specific exercise combined with other programs should be considered for prevention of DM complications.

Keywords: Type 2 diabetes, Ankle-brachial index, Leg microcirculation, Buerger's exercise

[1] M.Sc.; Faculty of Physical Therapy, Mahidol University, kanokporn.pad@student.mahidol.ac.th

[2] Dr.; Department of Physical Therapy, Faculty of Physical Therapy, Mahidol University, nantinee.nua@mahidol.ac.th

[3] Dr. M.D.; Department of Community Medicine, Faculty of Medicine Ramathibodi Hospital, Mahidol University vijj9@hotmail.com

[4] Dr.; Department of Occupational Therapy, Faculty of Physical Therapy, Mahidol University, kannika.per@mahidol.ac.th

[5] Dr.; Department of Occupational Therapy, Faculty of Physical Therapy, Mahidol University, peeradech.thi@mahidol.ac.th

Introduction

The prevalence of non-communicable diseases (NCDs) especially type 2 diabetes mellitus (T2DM) has been increasing in developed countries included Thailand. Diabetes patients who commonly have prolonged hyperglycemia lead to abnormal vascular function and develop its complication especially peripheral arterial disease (PAD) (Hamburg & Balady, 2011). Previous studies reported that the rate of PAD is increased two to fourfold in T2DM (John & Rathiga, 2015). In later stage of disease, foot ulceration is frequently develops which can lead to wound infection, and tissue necrosis. Nearly 90% of diabetes-related lower limb amputations, which is the most devastating endpoint of the disease, were preceded by foot ulcer (Chang, Chang, & Chen, 2015). In addition, diabetic foot ulceration is often resistant to treatments such as operation and infection control despite absence of significant PAD. These problems are required long-term care which result in high public health cost and have a huge impact on the quality of life. Therefore, potential therapeutic approach for prevention of diabetic complications is the most important way to improve clinical status and quality of life of the patients.

Aerobic exercise is typically recommended as a guideline in the management of diabetes mellitus whether or not has vascular complications. Several studies reported that aerobic exercise can reduce cardiovascular risk factors, improve peripheral perfusion, and also prevent or modify diabetes-related lower limb amputations (Williams, Harding, & Price, 2007) (Madden, Lockhart, Cuff, Potter, & Meneilly, 2009). However, there are many barriers that restrict or prevent patients with diabetes from participation in aerobic exercise program such as availability of programs, time constraints, patient willingness to participate and logistical issues, etc. Buerger's exercise or Buerger-Allen exercise was first presented by Leo Buerger in 1926, and modified by Arthur Allen in 1930. Buerger's exercise aims to enhance peripheral circulation of the lower extremity, originally in people who have Thrombo-angiitis Obliterans (TAO) or Buerger's disease. A gravitational force is applied from changes in position to expel and propel the blood columns alternately leading to improved blood circulation subsequently (Chang, Chang, Hwang, & Chen, 2015). Buerger's exercise has been considered as a treatment for improving lower limb circulation. It has been recognized that this kind of exercise might increase the rate of blood flow, clear away stagnant blood and help establish collateral circulation to the ischemia area (Chang, Chang, & Chen, 2015). Therefore, Buerger's exercise is seem to be the alternative management for prevention diabetic complications. However, it is not recommended frequently because of the lack of scientific studies to investigate the responses of Buerger's exercise on lower limb

circulation in diabetes patients. The aim of this study was to investigate the effects of Buerger's exercise on leg microcirculation in T2DM.

Methods

Participants: Participants with T2DM, the age between 40 to 70 years, were recruited around Nakhon Pathom area. T2DM was diagnosed by the physician based on the criteria of the American Diabetes Association. The exclusion criteria was individuals who have serious complication including coronary heart disease, chronic kidney disease, smoking and intermittent claudication. Eligible participants were notified all procedures and were signed consent form before they participate in the study. All procedures in the study have been approved by the Institutional Review Board at Mahidol University.

Outcome measurements: On the study day, participants were arrived at the lab with 4-hour fast and rested in supine position for 10 min before beginning all procedures. Ankle-brachial index (ABI) was obtained using automated vascular testing devices (VP-1000 plus, OMRON Healthcare, Kyoto, Japan). Blood pressure cuffs were wrapped at both side of arms and ankles. Ankle blood pressure were obtained automatically in 1-2 min. ABI was calculated as ankle systolic blood pressure divided by brachial systolic blood pressure. The laser Doppler fluximetry (DRT4 MoorLAB, Moor Instrument, Devon, UK) was used to measure leg microcirculation as perfusion unit (PU). Two electrodes were attached on the left lower leg and dorsum of foot (between 1st – 2nd metatarsals). All outcome measurements were obtained at baseline, post-exercise immediately and after 8-week exercise program.

The participants were performed one session of Buerger's exercise with the researcher. During the exercise, perception of leg pain or fatigue was evaluated by using the 4-point Claudication Pain Rating Scale (Brunelle & Mulgrew, 2011) for safety. The 4-point Claudication Pain Rating Scale is an ordinal scale rating 1-4; 1= slightly leg fatigue, 2= moderate leg fatigue, 3= leg pain occurs, and 4= severe leg pain. If individual can be following the exercise without leg pain or severe fatigue, individual was completely one session of exercise. In participants who rated a score of 3 to 4 points on the Claudication Pain Rating Scale were asked to terminate on the exercise protocol. All participants were assigned to follow Buerger's exercise at least 3-5 days/week for 8 weeks. *Blood samples:* Blood sampling was collected approximately 3 milliliters in all participants after a 12-h fast by venipuncture. Metabolic risk factors including fasting glucose, lipids and lipoproteins were analyzed from plasma sample as the demographic data.

Intervention: Buerger's or Buerger-Allen exercise was conducted in the study based on standardized procedures in the previous studies (Allen, 1930) (Chang, Chang, Hwang, & Chen, 2015). The exercise consists of three steps; *Step1* lies in supine position with both legs elevated 45° to 60° and supported by pillows or triangle box for 3 min; *Step2* sits on the edge of bed with the feet hanging down, performs active ankle exercises include dorsiflexion, plantar-flexion, inversion, eversion, flexes and extends the toes, rhythmically repeat for 3 min; and *Step3* lies in supine position for 3 min as shown in Figure 1. All three steps are completed into a cycle of exercise, and the total cycle is repeated for 3-5 times per session. In addition, the exercise would be progressed (Meheni, 2012) at the 3th to 5th cycles including active resisted ankle exercises in the elevated (*Step1*) and dependent positions (*Step2*) by using Theraband® or elastic bands as given in Figure2. The exercise brochure and record form were provided in all participants for 8-weeks exercise. Moreover, the researchers checked the frequency of exercise by telephone every week for 8 weeks.

Figure 1. Buerger's protocol consists of (A) *Step1*, (B) *Step2*, and (C) *Step3* into a cycle of exercise.

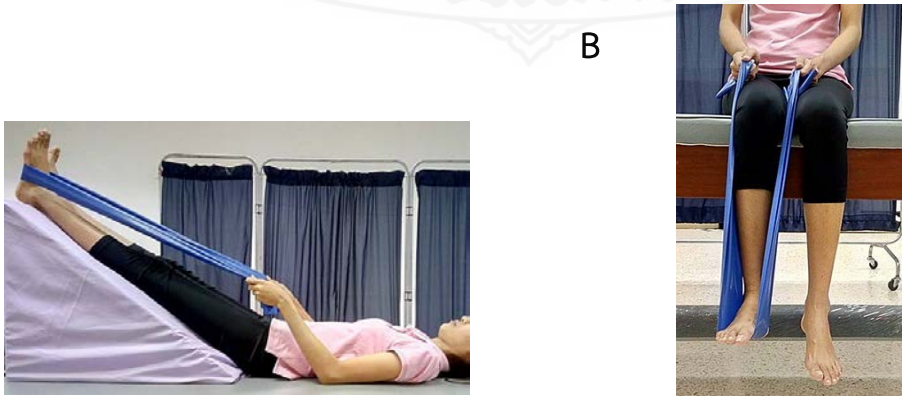

Figure 2. The progression of exercise (A) in elevated, (B) and dependent positions.

Statistical analysis: The Statistical Package for Social Science (SPSS) software for windows was used for analyzing the data. The statistical significance sets at p-value less than 0.05 ($p<0.05$). All analyses were tested the normal distribution by using Kolmogorov-Smirnov Goodness of Fit test. One-way ANOVA was used to investigate the changes of dependent variables at baseline, post-exercise, and 8-weeks follow up sessions. In the case of a significant F-value, LSD was conducted to identify significantly difference among mean values as the post-hoc test. All data are shown as mean ± standard deviation.

Results

Average age of the study participants was 55±7 years. Ten participants were 2 males (20%) and 8 females (80%). Details of baseline subject's characteristics were shown in Table 1. Mean and standard deviation of ABI was 1.2±0.06 at baseline, 1.2±0.07 at post-exercise, and 1.13±0.08 at 8-week post-exercise. There are no significant difference of ABI at post-exercise (F=2.66, p=0.93) and 8-week follow up (F=2.66, p=0.055) compared to baseline. Mean and standard deviation of leg microcirculation was 14.8±7.4 at baseline, 26.2±8.6 at post-exercise, and 19.9±11.9 at 8-week follow up. Leg microcirculation was statistically significant difference immediately post-exercise (F= 2.62, p=0.033) compared with baseline as shown in Figure 3. Details of changes in ABI and leg microcirculation after following Buerger's exercise were given in Table 2.

Table 1. Baseline characteristics of the study participants (n = 10)

Variables	mean ± SD
Gender [n (%)]	
Female	8 (80%)
Male	2 (20%)
Age (Years)	55 ± 7
Weight (kg)	72 ± 12
Height (m)	1.6 ± 0.1
Body mass index (kg/m²)	28.4 ± 3
Waist circumference (cm)	93 ± 7
Systolic blood pressure (mmHg)	130 ± 17
Diastolic blood pressure (mmHg)	75 ± 6
Heart rate (beats/min)	70 ± 15
Fasting blood glucose (mg/dl)	142 ± 28
Cholesterol (mg/dl)	166 ± 31
Triglyceride (mg/dl)	45 ± 6
Low-density lipid cholesterol (mg/dl)	104 ± 42
High-density lipid cholesterol (mg/dl)	130 ± 23

Values are mean ± standard deviation

Table 2. Changes of ABI and leg microcirculation after following Buerger's exercise

Variables	Baseline	Post-exercise	8-weeks follow up
Ankle systolic blood pressure (mmHg)	159 ± 15	162 ± 12	150 ± 12
Ankle diastolic blood pressure (mmHg)	78 ± 8	83 ± 7	78 ± 8
Ankle mean arterial pressure (mmHg)	107 ± 11	110 ± 8	104 ± 9
Ankle pulse pressure (mmHg)	81 ± 14	79 ± 11	73 ± 11
Ankle-Brachial Index	1.2 ± 0.06	1.2 ± 0.07	1.13 ± 0.08
Leg microcirculation (PU)	14.8 ± 7.4	26.2 ± 8.6*	19.9 ± 11.9

Values are mean ± standard deviation *$p < 0.05$ versus baseline

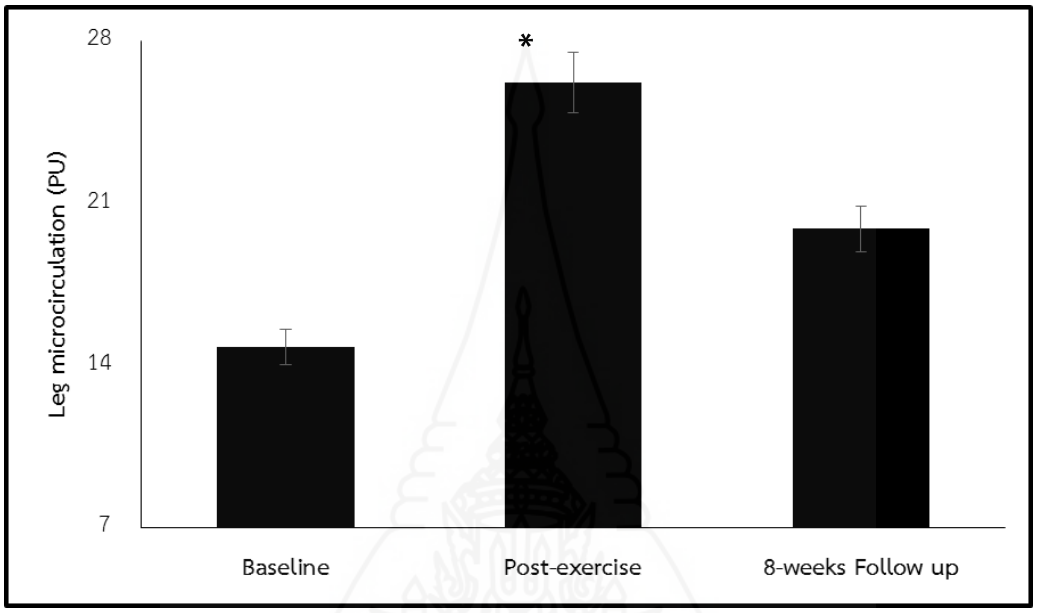

Figure 3. Changes in leg microcirculation after following Buerger's exercise

Discussion

The main finding of this study was immediately increased leg microcirculation after following one session of Buerger's exercise. These finding is proved the assumption of Buerger's exercise. A gravitational force from position changes is helped to expel and propel the blood columns alternately, which can eventually facilitate blood circulation to the peripheral (Chang, Chang, Hwang, & Chen, 2015). In this study, we also applied active resisted ankle exercise in *Step1* and *Step2* of Buerger's exercise *as* the progression of exercise. We add active exercise to the original protocol because muscle pumping action may increase leg microcirculation during rhythmical movement as described in the studies of Delp & Laughlin (1998).

According to the studies of Niebauer (1996) and Green (2006), the vascular adaptation measured by flow-induced vasodilation mechanism can occur within 8 week. Therefore, the duration of our Buerger's exercise was assigned to be 8 weeks. To the best of our knowledge, this is the first study to evaluate leg circulation after Buerger's exercise. Home-based exercise program is hard to control the intensity of exercise. However, we gave our subjects the exercise log to control the compliance to exercise.

Beneficial effects of Buerger's exercise in aspect to improve lower limbs circulation were consistent with the previous studies of John & Rathiga (2015) and Chang, et al. (2016). In addition, Buerger's exercise combined with resistance exercise, and health-promoting program also enhanced lower limbs perfusion (Meheni, 2012) and reduced the risks of foot ulceration in T2DM (Chang, Chang, Hwang, & Chen, 2015) (Chang, et al., 2016). These finding indicated that Buerger's exercise should be determine as the tentative treatment and the prevention of diabetic neuropathy, peripheral arterial disease, and foot ulceration in T2DM.

Suggestion

The novel finding of the present study was that Buerger's exercise immediately improved leg perfusion. However, the 8-week program did not show significant changed in ABI and leg microcirculation. One possible reason was that the exercise was home-program. The intensity of training may not reach the target. Therefore, the responses on ABI and leg microcirculation after following Buerger's exercise for 8 weeks were not noticeable different. The supervised Buerger's exercise would be necessary for further study.

References

Allen, A. (1930). Recent Advances in the Treatment of Circulatory Disturbances of the Extremities: Results Obtained in the Peripheral Circulatory Clinic of the Massachusetts General Hospital. *Ann Surg, 92*(5), 931-46.

Brunelle, C., & Mulgrew, J. (2011). Exercise for intermittent claudication. *Phys Ther, 91*(7), 997-1002.

Chang, C., Chang, C., & Chen, M. (2015). Effect of Buerger's exercises on improving peripheral circulation: a systematic review. *Open Journal of Nursing, 5*, 120-8.

Chang, C., Chang, C., Hwang, S., & Chen, M. (2015). Effects of Buerger Exercise Combined Health-Promoting Program on Peripheral Neurovasculopathy Among Community Residents at High Risk for Diabetic Foot Ulceration. *Worldviews Evid Based Nurs, 12*(3), 145-53.

Chang, C., Chen, M., Shen, J., Lin, Y., Hsu, W., & Lin, B. (2016). A quantitative real-time assessment of Buerger exercise on dorsal foot peripheral skin circulation in patients with diabetes foot. *Medicine, 95*(46), 1-5.

Delp, M., & Laughlin, M. (1998). Regulation of skeletal muscle perfusion during exercise. *Acta Physiol Scand, 162*, 411-9.

Green, D. N. (2006). Cardiac and vascular adaptation to exercise. *Curr Opin Clin Nutr Metab Care, 9*, 677-84.

Hamburg, N., & Balady, G. (2011). Exercise rehabilitation in peripheral artery disease: functional impact and mechanisms of benefits. *Circulation, 123*(1), 87-97.

John, J., & Rathiga, A. (2015). Effectiveness of Buerger Allen Exercise to Improve the Lower Extremity Perfusion among Patients with Type 2 Diabetes Mellitus. *International Journal of Current Research and Academic Review, 3*(4), 358-66.

Madden, K., Lockhart, C., Cuff, D., Potter, T., & Meneilly, G. (2009). Short-term aerobic exercise reduces arterial stiffness in older adults with type 2 diabetes, hypertension, and hypercholesterolemia. *Diabetes care, 32*(8), 1531-5.

Meheni, S. (2012). Comparison between Two Vascular Rehabilitation Training Programs for Patients with Intermittent Claudication as a Result of Diabetic Atherosclerosis. *Bull Fac Ph Cairo Univ, 17*(1), 7-15.

Niebauer, J. C. (1996). Cardiovascular Effects of Exercise: Role of Endothelial Shear Stress. *JACC, 28*(7), 1652-60.

Williams, D., Harding, K., & Price, P. (2007). The influence of exercise on foot perfusion in diabetes. *Diabet Med, 24*(10), 1105-11.