ORIGINAL ARTICLE

Effect of Ankle Pumping Exercise to Ankle Brachial Index in Type 2 Diabetes Mellitus Patients with Ulcer

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ABSTRACT

Objectives: To analyze the effect of ankle pumping exercise and other factors such as gender, age, duration of Diabetic Mellitus, nutritional status, history of smoking, hypercholesterolemia, ulcer degree and HbA1c to Ankle Brachial Index (ABI) in type 2 Diabetes Mellitus patients with diabetic ulcer.

Methods: The quasi experimental design study with consecutive sampling and one-week interval of intervention was conducted in this study. Analysis of changes in pre-post test ABI used paired t-test while other factors were measured with multiple regression.

Results: Ankle pumping effect to right foot after exercise as 0.048 while ABI 0,017 on left foot and ABI 0.038 after exercise on both feet. It was not a statistically significant increase on both feet (p>0. 05). The relations of multifactors to ABI : Gender 0.47(p 0.829), age 51.32 (p 0.743), duration of DM 83.16(p 0.490), BMI 21.82 (p 0.452), history of smoking 0.47 (p 0.769), hypercholesterolemia 0.11 (p 0.195), degree of ulcer 3.74 (p 0.635), HbA1c 0.89 (p 0.798).

Conclusions: There is statistically no effect of ankle pumping exercise to ABI. We also did not find an effect of gender, age, and duration of DM, nutritional status, history of smoking, history of hypercholesterolemia, ulcer grade and HbA1c to increase of ABI in diabetic subjects with foot ulcer after ankle pumping exercise. Nevertheless, we found a sufficiently noted increase of systolic blood pressure of Dorsal Pedis Artery and Posterior Tibia Artery after ankle pumping exercise in type 2 DM subjects although this is not statistically significant.

Keywords : *Diabetes Mellitus, diabetic ulcer ankle pumping, ankle-brachial index.*

INTRODUCTION

Diabetes Mellitus (DM) is an metabolic disease characterized with insulin secretion disturbance and/or insulin work.[1] DM is divided to type 1 which is autoimmune or idiopathic, caused by destructed beta; type 2 with various causes of which insulin resistance is dominant.[1, 2] Type 2 is the most common DM as 85%. [3]

The numbers of patients that suffer from type 2 DM worldwide is estimated between 170 to 200 million by 2002 of which one-third live in developing countries. This number is estimated be higher up to 300 million by 2025 of which one-third will live in India and China. In Indonesia, WHO predicted an increase of

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diabetic patients from 8.4 millions by 2000 to 21.3 millions by 2030 so that will put this country in fourth position after India, China, United States of America. [4]

A study in 2000 showed a high increase of prevalence of DM. In Jakarta, prevalence increased from 1.7% by 1982 to 5.7% in 1993 and 12.8% by 2001.[1]

This high prevalence and impacts of DM to the quality of human resources and health cost should be concerning to government and community to overcome this issue particularly the complications resulting from DM.[1]

Acute complications of DM are diabetic ketoacidosis, non-ketosis hyperosmolar and hypoglycemia while chronic complications are macroangiopathy 30.5% such as coronary artery disease 18.1%,, stroke 9.5% and peripheral artery disease (PAD) 24.5%[5]; microangiopathy such as diabetic retinopathy 48%, diabetic nephropathy 33% and diabetic neuropathy 63%.[1,5,6,7,8]

PAD is four times more in DM patients[9] and 20% of them will die in two years after symptoms appeared where the most cause is myocardial infarct.[7] PAD gives common symptom as intermittent [7] or ulcer and gangrene leading to amputation[10]; an average of length of diabetic foot care was 30 days in 1998.[11] Ankle-brachial index (ABI) roles as a simple test to measure vascularization of lower extremity to upper extremity.[8]

Management of DM includes education, diet, exercise, oral anti-diabetic and insulin.[12] There is foot exercise training in diabetic mass exercise which is aimed to improve lower extremity vascularization ; ankle, plantar foot and toes.[13]

This study aims to know the effect of ankle exercise, which is plantar flexion and dorsal flexion of ankle by ABI in diabetic patients with ulcer which in 2007, 111 (34%) diabetic ulcer patients out of 327 diabetic patients admitted in internal medicine ward at Cipto Mangunkusumo Hospital.[14]

METHODS

The study design was quasi experiment (pre and post test) to know the effet of ankle pumping exercise to ABI in type 2 DM who admitted for diabetic ulcer.

This study had an Ethical Clearance from Ethic research commitee of Faculty of Medicine of University of Indonesia

The exercise was done in internal medicine ward of Cipto Mangunkusumo Hospital from January to October 2010.

This study was using a form consisting ABI measurements and influencing factors. Medical devices used were Handheld Doppler and probe, gel, body weight scale, body height scale, goniometer, Littman stetoscope, and Reister sphignomanometer

Sample population was picked consecutively, with 30 as the preliminary sample. There is no prior study or experience show improvement to ABI in diabetic patients. Total sample was 34 subjects.

Subjects should meet criterias as follow; in-patient type 2 DM, male and female, non-weight bearing diabetic ulcer foot, 35 to 60 year-old, ABI from 0.6 to 1, *Manual Muscle Testing* (MMT) at least 3, agree and asign to participate in this study. Subjects were excluded if they have history of surgery of lower limbs which influences range of ankle joint motion; dorsiflexion and plantarflexion , have a Congestive Heart Failure (CHF) Functional Class III and IV; untreated Deep Vein , cognitive and memory disturbances, in treatment of vasodilator including cilostazol dan ACE inhibitor, limited motion of dorsiflexion and plantarflexion of ankle. Subjects were also excluded from study if they didn't exercise in 3 consecutive times, exercise less than a week due to discharge or underwent surgery that influences ankle motions.

The effect of ankle pumping to ABI was measured by paired test and effect to blood pressure of Dorsal Pedis Artery and Posterior Tibial artery as well. The effect of age, gender, length of DM, Body Mass Index, smoking, hypercholesterolemia, ulcer grade and HbA1c to ABI was analyzed by multiple regression.

RESULTS

Nineteen diabetic subjects were participating in this study. Mean of age was 51,3 year-old, half

of subjects were not smoking (52.6%), most of the subjects didnt have hypercholesterolemia (89.5%), mean of BMI was 21.82. This study found uncontrolled glycemic with HbA1c mean 9.4 and mean of ulcer grade was > 3.74 (see table 1)

Thirteen subjects had ulcer at right foot (68.4%) and 6 subjects had it at left foot (31.6%). Three subjects (15.79%) had ABI < 0.9. Table 2 showed the result of ankle pumping effect to right foot after exercise as 0.048 while ABI 0.017 on left foot and ABI 0.038 after exercise on both feet. It was not statistically significant increase on both feet (p>0.05).

Table 1. Comparison of mean JPS and TTDPM of affected knee (control) and affected knee after treatment

VARIABLE	N=19 (%)	Mean (SD)	Median (range)
Gender			
Male	9 (47.4)		
Female	10 (52.6)		
History of smoking			
Yes	9 (47.4)		
No	10 (52.6)		
Hypercholesterolemia			
Yes	2 (10.5)		
No	17 (89.5)		
HbA1c (%)			
< 4	0 (0)		
4-6	2 (10.5)		
>6	17 (89.5)		
Age (year)		51.3 (6.95)	53 (37-59)
Duration of DM (months)		83.16 (62.29)	
(8-216)			
BMI (kg/m2)		21.82 (4.29)	20.94 (16.5-31.2)
Ulcer grade		3.74	4.0 (2-5)

Effect of multi-factors such as gender, age, duration of DM, nutritional status, history of smoking, history of hypercholesterolemia, ulcer grade and to ABI after exercise is showed in table 3. There was no statistically significance effect of those factors to ABI after exercise (p>0.05).

Tabel. 2. Effect of Ankle Pumping to Ankle-Brachial Index

	N(%)	Mean (SD)	Med (range)	Wilcoxon Z	p (2-tailed)
Right					
Pre	13(68.4) 13	0.947(0.117)	1 (0.63-1)		
Post	(68.4)	0.995(0.084)	1 (0.85-1.15)		
Increase		0.048		-1.262	0.207
Left					
Pre	6 (31.6)	0.975(0.061)	1 (0.85-1)		
Post	6 (31.6)	0.992(0.059)	1 (0.92-1.09)		
Increase		0.017		-1.069	0.285
Right-Left					
Pre	19 (100)	0.956(0.102)	1 (0.63-1)		
Post	19 (100)	0.994(0.075)	1 (0.85-1.15)		
Increase		0.038		-1.649	0.099

Tabel 3. Effect of multi factors to Ankle-Brachial Index

	Mean (SD)	b	95%CI of b	p of b (2-tailed)
ABI increase on ulcer foot	0.038 (0.096)			
Gender	0.47 (0.51)	0.124	-0.209 – 0.255	0.829
Age	51.32 (6.95)	0.105	-0.008 – 0.011	0.743
Duration of DM (month)	83.16 (62.29)	-0.246	-0.002 – 0.001	0.490
BMI	21.82 (4.29)	-0.307	-0.026 – 0.13	0.452
History of smoking	0.47 (0.513)	0.162	-0.094 – 0.254	0.769
History of hypercholester-olemia	0.11 (0.315)	-0.433	-0.343 – 0.080	0.195
Ulcer grade	3.74 (0.733)	-0.183	-0.133 – 0.085	0.635
HbA1c (%)	0.89 (0.315)	0.080	-0.182 – 0.230	0.798

There were some subjects whose blood pressure could not be measured due to ulcer area on foot or subjects underwent amputation (table 4). There was increase of systolic blood pressure of Dorsal pedis artery on ulcer foot after exercise as 2.22 mmHg, while on healthy foot as 7.35 mmHg. An increase of systoleic Posterior tibial artery on ulcer foot was also found as 6, 17 mmHg, on the healthy foot as 5.88 mmHg, this number, however, is not statistically significant. (p>0.05).

Tabel 4. Change of Systolic blood pressure of A. Dorsalis Pedis dan A. Tibialis Posterior after exercise

	N	Mean (SD)	Med (range)	Wilcoxon Z	p (2-tailed)
A.DPA	18	132.22(27.56)	130 (80-180)		
A.DPAPE	18	134.44(23.82)	130 (100-190)		
Increase		2.22		-0.230	0.818
A.DPN	17	138.53(31.21)	120 (100-190)		
A.DPNPE	17	145.88(31.68)	140 (90-210)		
Increase		7.35		-1.056	0.291
A.TPA	17	129.12(32.67)	130 (60-180)		
A.TPAPE	17	135.29(28.48)	130 (80-180)		
Increase		6.17		-1.371	0.170
A.TPN	17	135.59(31.67)	135 (80-190)		
A.TPNPE	17	141.47(26.09)	135 (100-190)		
Increase		5.88		-1.002	0.316

A.DPA : A. dorsalis pedis affected
A.DPAPE : A. dorsalis pedis affected post exercise
A.DPN : A. dorsalis pedis normal
A.DPNPE : A. dorsalis pedis normal post exercise
A.TPA : A. tibialis posterior affected
A. TPAPE : A. tibialis posterior affected post exercise
A.TPN : A. tibialis posterior normal
A.TPNPE : A. tibialis posterior normal post exercise

DISCUSSION

This study found an equal number of male and female subjects and an increase of subjects of DM as ageing , similarly to result of Chew and Leslie (2006)[12] that showed an increasing prevalence as older age, and there was no different gender, prevalence of female is 17% and male 1.6% in age 20 - 39 year-old, became 6.1% and 6.8% by 40 year old and more by 50 - 59 as 12.4% dan 12.9%.

Mean of age 51.3 year-old is regarding to Chew dan Leslie (2006)12 from 50 to 59. The older subject, the higher prevalence of DM is resulting from decrease of mucles mass as 3 – 5% starts from fouth decade leads to less physical activity results in insulin resistance.[15]

This study showed that subject would have diabetic ulcer after suffering DM for 7 years, which is different from Rao et.al (2004) who found that risk of having ulcer was higher after 10 years. In other variable, we found the same result with Rao that the higher HbA1c, the higher risk of diabetic ulcer (>6).[10]

Mean of BMI 21.82 which is normal value, different to prior study that found a relationship between obesity, BMI >25, with DM as 80% type 2 DM had obesity. However, BMI does not accurately describe fat distribution and is not a good predictor for DM.[7] There is population within insulin resistance having normal BMI which is called Metabolically Obese, Normal Weight (MONW) and having localized fat at back area. [16]

We found 17 subjects (89.5%) with no history of hypercholesterolemia This is characteristic of old diabetic patients having diabetic dyslipidemia which consists of steady total choleterolemia with high trigliseride and LDL and low HDL[7] All male subjects in this study have history of smoking as a predisposition factor for DM.[12]

We found a slight increase (<10%) of ABI which was not significant statistically. This result is different to Gardner's (1997)[17] that found correlation between physical activities with ABI. Physical activity is referring to Minnesota Leisure-time Physical Activity Questionnaire[18] that consists of walking and cycling, while this study used ankle pumping in non weight bearing position. This slight increase could be resulted from small sample having ABI < 0.9 (3 subjects = 15.79%) so that normal ABI in more subjects leads to less possibility of more increasing ABI.[19] This result could be also resulted from changed of frequency quantitatively although there was no change in the repetition of exercise. In Flahr's study (2010) that performed 4 set exercise and 10 repetitions twice a day for 12 weeks, they correlated ankle pumping to ulcer healing with no correlation found by the study. We use one week exercise with consideration that longer such exercise will lengthen immobilization and also referring Maiorana et al (2003) that found an endothelial improvement after one week exercise in animal.[19] Changes of exercise frequency to once a day with 100 repetitions will cause fatigue in diabetic patients who usually have sedentary lifestyle resulting an inadequate ankle pumping exercise[12]. The insignificant result could be resulted from focus of the study which is more study in macroangiopathy, PAD whereas diabetic ulcer can be occurred in neuropathy regarding to this study's result ulcer location is typically within neuropathy.[7,20] Therefore when motor neuropathy occurred, pumping strength is not as good as the healthy foot although MMT more than 4. In this case, ankle pumping will be insufficiently optimal.

We found no effect of gender, age, duration of DM, nutritional status, history of smoking, history of hypercholesterolemia, ulcer grade and HbA1c to ABI which is different from Li J (2007)[21] This is resulting from normal ABI in most subjects while HbA1c mean 8.3 in ABI <0.9, which is similar to Selvin (2006)[22] that found correlation between low (<0.9) with high HbA1c.

There was also a high increase of systolic blood pressure of Dorsal pedis artery and Posterior Tibial Artery on the affected and healthy foot but statistically insignificant. Small sample could be the cause of this result. In 2 subjects, blood pressure measurement could not be conducted due to ulcer located on dorsum pedis and maleolus while in 2 other patients the amputation is in the contalateral foot. We found a higher pressure on Dorsal pedis artery on healthy foot which was also found in the Posterior tibial artery. This may be caused by ankle motion affecting the Dorsal pedis artery while Posterior tibial artery is not, therefore increase blood pressure is relatively same on both feet.

This study was conducted for in-patients because we need to observe and monitor the exercise. However, this may cause less recruitment of subjects (n=19) who could not meet the normal sample measurement (n=34). Limited time of research is another constraint

so we decided to limit the recruit sample to 20. At the time 19 subjects recruited we did pre analysis and found that the amount of sample is not statistically different. We assumed that although we add one to 20 subjects the result will not be changed significantly.

At the beginning we made 40 to 60 year-old as an inclusion criteria but because of sample limitation in the 9 months running study changed the criteria and allow the greater range of age from 35 to 60 year-old. Schedule of wound dressing became another reason to change protocol of exercise, in which 3 times a day with 30 repetitions was not effectively done due to unfitted time to wound dressing change. Modern dressing used in wards had once change time so that we had to change the frequency to be once daily with 100 repetitions at the time of dressing removal. Clinically practice, wound dressing was a constraint in doing ankle motion so that we needed to modify the protocol.

We didn't include diabetic dyslipidemia and did not examine sensory neuropathy using tuning fork and Semmes Weinstein monofilament regarding to Li et.al statement (2007)[21] that those variables had no effects.

CONCLUSIONS

A slight increase of ABI from this study shows that there is statistically no effect of ankle pumping exercise to ABI. We also did not find an effect of gender, age, duration of DM, nutritional status, history of smoking, history of hypercholesterolemia, ulcer grade and HbA1c to the improvement of ABI in diabetic subjects with foot ulcer after ankle pumping exercise. Nevertheless, we found a sufficiently increase of syctolic blood pressure of Dosal Pedis Artery and Posterior Tibial Artery after ankle pumping exercise in type 2 DM subjects although they are not statistically significant.

We suggest to include more subjects with ABI score <0.9 for further study to find more improvement ABI score (minimal 10%) to have significant change. It is also important to increase frequency, repetition and duration of exercise. Another suggestion coming from this study's result is to do a further study for gait analysis in diabetic patients to evaluate possible answer of why most of diabetic ulcer is more common on the right foot.

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