ISSN 0975-2366
https://doi.org/10.31838/ijpr/2019.11.02.097

Research Article

The Effects Of Poco-Poco Dance On The Executive Functions Of Type 2 Diabetes Mellitus Patients With Mild Cognitive Impairment Achieved Through Improvements In Neuronal Functions And Plasticity

RIA MARIA THERESA,[1*] MARTINA W. NASRUN,[2] CZERESNA HERIAWAN SOEJONO,[3] AND INDANG TRIHANDINI.[4]

[1]Faculty of Medicine, Jakarta Veterans National Development University, Jakarta – RMT.
E-mail id: riamaria@upnvj.ac.id
[2]Department of Psychiatry, Faculty of Medicine, Universitas Indonesia, Jakarta – MWN.
[3]Department of Internal Medicine, Faculty of Medicine, Universitas Indonesia, Cipto Mangunkusumo Hospital, Jakarta – CHS
[4]Department of Demographics and Biostatistics, Faculty of Public Health, Universitas Indonesia, Depok – IT.

Received: 25.04.19, Revised: 25.05.19, Accepted: 25.06.19

ABSTRACT

Increased production of ROS in T2DM patients causes neuronal cell destruction which reduces cognitive function, especially the executive function which are necessary for completing normal daily activities. Poco-poco dance as a popular folk dance is easy to do, inexpensive, and adheres to Indonesian cultural norms can directly or indirectly achieve this by improving neuroplasticity. This research randomized 32 T2DM patients with mild cognitive impairment, aged 45-59 years old, with more than 9 years of education into two groups, each consisting of 16 patients. This research was performed in Depok between December 2013-July 2014. The intervention group received a 30 minutes biweekly dance therapy for 12 weeks. Both groups received the standard therapy for T2DM. Mild cognitive impairment was assessed using the NDVCI-T2DM form. The patient's executive function was assessed by the TMT-B. All patients were evaluated for their HbA1c, LDL, triglycerides, total cholesterol, and F2 isoprostane levels. Neuroplasticity was measured by the NAA/Cr ratio through MRS at the beginning and the end of the research. The intervention group experienced significant differences in their executive function ($p = 0.016$), the neuroplasticity of the right prefrontal ($p = 0.001$), left prefrontal ($p = 0.001$), left parietal ($p = 0.007$), right hippocampus ($p = 0.003$) and HbA1c ($p = 0.02$), LDL ($p = 0.005$), triglycerides ($p = 0.002$) and F_2 isoprostane (0.001) levels. Although the HbA1c ($p = 0.001$) and F2 isoprostane ($p = 0.001$) levels decreased, there were no significant decreases in the NAA/Cr ratio of all lobes. The ABI was 37.5% and the NNT was 3. 37.5% of patients experienced improvements in their executive functions, either by directly or indirectly improving the brains' neuroplasticity.

Keywords: T2DM, executive function, mild cognitive impairment, neuroplasticity, poco-poco dance.

INTRODUCTION

The current number of people with type 2 diabetes mellitus (T2DM) in Indonesia is quite high at 8.4%, and is expected to increase to 21.3 % by 2030.[1] People with diabetes mellitus type 2 have a 4-fold larger risk to develop Non Dementia Vascular Cognitive Impairment than people without diabetes.[2] The degree of cognitive impairment in T2DM is measured through psychometric tests of Non Dementia Vascular Cognitive Impairment, validated by Martina in 2007.[2]In T2DM with sustained hyperglycemia, the production of free radicals will continue to increase, which in turn, will increase the amount of reactive oxygen species (ROS) in all tissues and result in cell destruction. Oxidative stress stimulates the peroxidation of lipids in lipoproteins with unsaturated fatty acids, especially low density lipoprotein (LDL). The reaction between ROS and protein in people with diabetes causes neuronal impairment caused by damage to the enzymes that are essential for metabolism. Lipid peroxidation damages the structure of membranes and cell death occurs as a result of the toxic reactions of 4-hydroxy 2 nonenal (4-HNE) and acrolein to neurons. However, regular physical activity has a direct protective effect against the oxidative stress in diabetes. Regular physical activity increases the blood flow to the brain, particularly the hippocampus. This is evident, in that after 3 months of physical activity, patients experienced improvement in verbal capabilities and memory.[3] The objective of this research is to discover whether an intervention in the form of the poco-poco dance can maintain or improve executive function.

Methodology

This was a randomized controlled trial (RCT) that analyzed data on from applying the poco-poco for

T2DM patient with mild cognitive impairment. The study was conducted in Depok, the study duration was 30 minutes, performed twice a week for 12 weeks. Laboratory tests (HbA1c, LDL, triglycerides, total cholesterol, F_2-isoprostane) and MRS examination (metabolite ratios of NAA/Cr) of 32 respondents who satisfied the inclusion criteria were completed.

$$n1 = n2 = 2\left[\frac{(Z\alpha + Z\beta) \times SD^2}{(X1 - X2)}\right.$$

Zα = Type 1 error = 5% expected significance, from the one way table we calculate it to be 1.64. Zβ = Type 2 error = 0.842 with an expected power of 80%.
SD= Standard Deviation for HbA1c, LDL, HDL, total cholesterol.

$X_1 - X_2$ = Minimal average discrepancy considered significant, Δ (average delta) Δ (average delta) for LDL, HDL, total Cholesterol, and HbA1c

Blood Examination	SD	Δ (delta value) n	LDL[95]
0,31		0,46	7
HDL[95]	0,12	0,86	14
Total Cholesterol[95]	0,25	0,64	2
HbA1c[96]	0,7	0,83	15

Sample Size

The minimal sample size used in this research was 15 patients, with an expected drop out rate of 30% the total sample size chosen was 20 patients for the intervention group and 20 patients forthe control group. The following formula used to calculate the minimal sample size for this research:[94]

Inclusion and Exclusion Criteria

The inclusion criteria are type 2 diabetes mellitus patients with mild cognitive impairment, aged between 45-59 years old, at least has graduated from middle school, are capable of performing the physical activities required (not blind nor paralyzed), were willing to participate in this research, and were able to agree to and sign an informed consent. While the exclusion criteria are patients with severe chronic diseases that may interfere with the research process (i.e. stroke patients), did not complete the preliminary examinations, are using pacemakers.

Results

The average age of the research subjects was 51 years old. 62.55% were female, the majority were married and were housewives, most have completed high school, were obese, did not smoke, had minimal physical activity, and the most common comorbidity was hypertension. The results of the psychometric examination (TMT B), laboratory tests and MRS examinations on subjects with T2DM and mild cognitive impairment were homogeneous. There was no significant difference between group of poco-poco dance intervention and the control group (See table 1).There was a significant difference in the results of psychometric tests TMT B after 12 weeks between the intervention group poco-poco dance and the control group. The intervention group, which danced for 30 minutes twice a week within a period of 12 weeks, showed significant improvement in the results of their performance tests TMT B (p = 0.016). The control group did not show any improvements in the results of their TMT B test and their executive functions (p = 0.99). The dance was able to improve the executive functions of 37.5% of T2DM patients with mild cognitive impairment (See table 2).In table 3, we discovered that there was a significant difference in the HbA1c and F_2 Isoprostan levels before and after the research for both groups (p <0.05). The HbA1c levels in the intervention group at the preliminary examinations was 7.55 and after 12 weeks it decreased to (p = 0.02), while in the control group at the preliminary exam was 10.00 and after 12 weeks it was 8,75 (p = 0.001). F_2-isoprostane levels significantly decreased after 12 weeks in both groups (p = 0.001). Although the total cholesterol levels had decreased substantially, it was not significant (p = 0,068). The intervention group experienced a significant decrease in the levels of HbA1c, LDL, triglycerides, and F2 Isoprostan before and after the dance intervention (p < 0.05). The control group also experienced a substantial decrease in their levels of LDL, triglycerides and total cholesterol, albeit not statistically significant (p > 0.05) (See table 3).The intervention significantly increased the NAA/Cr ratio in the prefrontal cortex of both hemispheres (p = 0.001). As stated in table 4, where the increase in the NAA/CR ratio indicates an increase in the neuronal activities of both prefrontal cortexes that leads to an improvement in their executive function. The patients also experienced a significant increase in the NAA/Cr ratio in the left parietal lobe of the intervention

group (p = 0.007). Which indicated an increase in the neuronal activities of the left parietal lobe. Whereas the control group experienced a decrease in the NAA/Cr ratio within the right parietal lobe and a slight increase in the left parietal lobe. And lastly, there was a significant increase in the NAA/Cr ratio in the right hippocampus of the intervention group (p = 0.030), which indicates an increase in the neuronal activities of the right hippocampus. The left hippocampus also experienced a slight, statistically insignificant increase.

Table 1. Characteristics of the Control and Intervention Groups.

Characteristics		Intervention Group		Control Group		p
		Mean (SD)	n (%)	Mean (SD)	n (%)	
Age (years)		51,63 ± 3,98	-	50,06 ± 4,58	-	0,311
Gender	Male	-	7 (43,7)	-	5 (31,3)	0,472
	Female	-	9 (56,3)	-	11 (68,7)	
Duration of DM						
		19±40,51		10±55,94		0,67
Marrital status						
	Married	-	15 (93,7)	-	16 (100)	0,317
	Widower	-	1 (6,3)	-	0	
Ethnicity				-		
	Javanese	-	7 (43,8)		7 (43,8)	
	Sundanese	-	1 (6,3)	-	2 (12,5)	
	Betawi	-	5 (31,1)	-	5 (31,1)	
	Batak	-	1(6,3)	-	0 (0,0)	
	Padang/ Minang	-	2 (12,5)	-	1(6,3)	
	Timor	-	0 (0,0)	-	1 (6,3)	
		13,31 ± 4,59				
Level		-		12,63 ± 2,89		0,616
Education	Middleschool	-	5 (31,3)	-	4 (25,0)	0,809
	Highschool	-	6 (37,5)	-	9 (56,2)	
	Diploma/ Bachelor	-	3 (18,7)	-	2 (12,5)	
	Masters/PhD		2 (12,5)	-	1 (6,3)	
		-				
Occupation	Civil Servant	-	4 (25,0)	-	3 (18,7)	0,950
	Employee	-	1 (6,2)	-	0 (0,0)	
	Businessman	-	0 (0,0)	-	2 (12,5)	
	Housewife	-	9 (56,3)	-	9 (56,3)	
	Retiree		2 (12,5)	-	2 (12,5)	

Table 2. Effects of Poco-poco dance against the TMT B score on T2DM with mild cognitive impairment.

Psycho metrics	Group	Before Intervention		Total	After Intervention		Total	p	ABI	NNT
		Normal n (%)	Impaired n (%)		Normal n (%)	Impaired n (%)				
TMT B	Intervention	1	15	16	8	8	16	**0.016**	**37.5 %**	**3**
				(100%)			(100%)			
	Control	2	14	16	2	14	16 (100%)	0.99		

Table 3. Effects of Poco-poco dance on the biomolecular parameters (levels of HbA1c, LDL, triglycerides, total cholesterol and F_2 Isoprostane).

Laboratory results	Groups	Median		p	
		Before	After	p1	p2
HbA1c	Intervention	7.55	7.30	**0.002**	0.218
	Control	10.00	8.75	0.001	
LDL	Intervention	154.00	138.80	**0.005**	0.485
	Control	152.00	145.88	0.276	
Triglyceride	Intervention	151.50	91.50	**0.002**	0.169
	Control	171.00	137.00	0.289	
Total Cholesterol	Intervention	226.00	218.50	**0.068**	0.738
	Control	229.00	213.50	0.178	
F2 Isoprostan	Intervention	184.48	39.15	**0.001**	0.763
	Control	130.03	41.00	0.001	

Discussion

The study subjects were homogenous in their characteristics, psychometric scores, glycemic index (HbA1c), lipid profiles (total cholesterol, LDL, triglycerides), oxidative stress (F_2- isoprostane) levels and metabolite ratios (NAA/Cr ratio) in the prefrontal cortex, parietal lobe, temporal lobe, occipital lobe and hippocampus. Both groups had similar characteristics. The dance is an expression of the soul which is fused and displayed in graceful movements. Movement is the foundation of dance, but dance and movement is not the same.[4] Dancing is not only copying movements, but the brain actually guides the dancers in order to establish links between the brain, movement, emotions and bodily expression.[4] Learning dance moves requires significant technical skills and interpretations skills from the person to be able to dance beautifully following the beat of the music. The learning process and the movements itself stimulates the brain to change its function. Dancing is one of the many physical activities that is capable of controlling the levels of blood glucose, regulate insulin secretion, decrease the risk of complications and cognitive impairment, in particular, the T2DM patient's executive functions.[5] Poco-poco dance is capable of increasing glucose transportation in muscles, improving insulin sensitivity, improving blood glucose regulation (which is caused by the movements of the muscles).[5-7]The poco-poco dance from Maluku is a good physical activity choice because it has rather complicated movements with a moderate difficulty level, is dynamic, respectful, fun and can be done by men and women, both in singles as well as in groups. While performing the dance movements, the patient needs to concentrate to the dance moves, but also must be able to predict the following movements, coordinate the movements, and be able to change from simple movements to more complex moves, all at the same time. They also need good visuospatial capabilities and kinesthetic abilities.

Table 4. Effects of Poco-poco dance intervention against the brain plasticity (NAA/Cr) in the prefrontal, parietal, temporal, occipital lobes and the hippocampus.

Lobes		Groups	Median NAA/Cr			p2
			Before	After	p1	
Prefrontal	Right	Intervention	2.31	3.94	**0.001**	**0.007**
		Control	2.59	2.28	0.148	
	Left	Intervention	2.25	2.87	**0.001**	0.093
		Control	2.46	2.51	0.892	
Parietal	Right	Intervention	2.26	2.41	0.918	0.712
		Control	2.90	2.25	**0.004**	
	Left	Intervention	2.04	2.42	**0.007**	0.531
		Control	2.22	2.24	0.352	
Temporal	Right	Intervention	1.74	1.73	0.488	0.127
		Control	1.90	1.51	0.224	
	Left	Intervention	1.50	1.47	0.635	0.899
		Control	1.64	1.49	0.049	
Occipital	Right	Intervention	1.94	1.99	0.756	0.274
		Control	2.11	1.88	0.293	
	Left	Intervention	2.05	1.90	0.204	0.387
		Control	2.92	1.99	0.806	
Hippocampus	Right	Intervention	1.64	2.02	**0.030**	0.068
		Control	1.76	1.58	0.920	
	Left	Intervention	1.49	1.74	0.518	**0.042**
			1.63	1.42	0.	

This dance is comprises of structured movements that changes according to the change in the beat of the song, which requires a combination of psychomotoric, sensoric, cognitive and emotional functions.[8-10]At first the patient follows the instructions of the dance instructor, while listening to the music, copying the complex movement sequences, and actively communicating with other participants.This dance requires good spatial ability to be able to adjust to the size of the room where the dance takes place and maintain a good distance with the other dancers.When learning dance movements, the occipital lobes are activated by paying visual attention to see and follow the movements of the instructor, recalling every detail of the movement sequence from the more simple to the more complex movements (this is done by the parietal lobes). While the temporal lobes listens to the rhythm of the song (auditory attention) and combines it with the dance movements and also is responsible in initiating and performing the movements, the prefrontal lobes adjusts the movement rhythm to the song's rhythm. This whole process is processed through the hippocampus.Many things about the human brain is still a mystery. Although it organizes our thoughts and controls every movement and sensory functions in your body, not many things are known about it. mysterious up to this day. It responsible for our ability to communicate, comprehend, change numbers or shapes, and imagine various forms. Physical activity and our executive functions are linked through increased brain function. Physical activity improves cardiorespiratory functions,

stimulates cell growth and the growth of new blood vessels, which will reduce the risk of brain atrophy and increase the brain volume.[11,12] Poco-poco dance is an emotional, cognitive and social process that can stimulate executive functions by retaining attention and concentration when performing complex movements. Learning dance movements, especially if performed in groups,requires more visual attention, remembering every detail of simple to complex motion sequences, the capability for auditoryattention, the capability for concentrating so that a person can decide to initiate and perform the movement, and attuning the movements to the rhythm of the song. Ratey et al.[13] stated that there are 3 levels of changes as a result of moderate aerobic physical exercise which are the cellular, biomolecular and systemic level. Therefore, physical exercise is responsible for changes in the synaptic plasticity, neurogenesis, and angiogenesis at the cellular level. Increased availability of neurotropin and brain cell growth factor occurs at the molecular level. The systemic effects are the changes in the nervous system that is responsible for the patient's ability to pay attention, learning, and memory. Regular physical exercise can increase neurogenesis in the brain, especially in the hippocampus. The hippocampus plays a role in the process of learning and memory, improving the survival of new neurons, cell proliferation, increased density and length of dendrits.[14]This study meets the three levels of change and there is evidence that there are changes in the plasticity of the synapse, in the increasing neuronal activity in the prefrontal and parietal cortex, and the hippocampus. There also seems to be an improvement in the results of the TMT B psychometric tests that assesses the executive functions of T2DM patients with mild cognitive impairment after the biweekly dance intervention for 12 weeks.Learning the dance movements requires the ability to pay visual attention, the ability to remember every detail of the simple and complex motion sequences, the ability to pay auditory attention and concentration, in order to initiate and perform the movements, adjust the movement to the rhythm of the song and performing it in groups.Both groups experienced a significant decrease in the HbA1c levels ($p = 0.02$ for the intervention group and $p = 0.01$ for the control group). There was also a significant decrease in F_2-isoprostane levels of both groups ($p = 0.001$). This change most likely was because of the increased physical activity in both groups that we did not control, i.e. other types of exercise, diets, and the different types of drugs used in either groups.There was a decrease in the lipid profile of the intervention group, which is indicated by the decrease in the total cholesterol ($p = 0.068$), LDL ($p = 0.003$), and triglyceride ($p = 0.001$) levels after intervention. The total cholesterol decrease was not statistically significant ($p = 0.068$), but there was a quantitative reduction in its levels after the intervention. This is why the intervention was able to improve the lipid profile, oxidative stress and antioxidant status in T2DM patients. Regular physical activity consisting of the poco-poco dance is capable of improving the patient's glycemic index, lipid profile and oxidative stress status in patients with T2DM. Dancing activates the muscles and increases aerobic activity, which causes an increase in glucose transportation, improves insulin sensitivity, and improves blood glucose control. In addition, glycogen and carbohydrates are broken down into CO_2 and H_2O, and the mitochondria will produce ATP. When dancing the poco-poco, there is an increase in the energy expenditure caused by the movement in skeletal muscles. Therefore, the dance intervention is able to reduce oxidative stress and can prevent damage to the enzymes required for the metabolism, and preventing subsequent damage to neurons. Performed on a regular basis, the dance provides protection against oxidative stress in T2DM patients.NAA/Cr ratios is used to describe the brain metabolites used in the research. A significant increase of that ratio was experienced in the right and left prefrontal cortexes ($p = 0.001$), left parietal lobes ($p = 0.007$) and right hippocampus ($p = 0.030$) after 12 weeks of the intervention, indicating that there are more active neurons in those areas. Physical activity affects the brain by increasing the growth of nerve cells (in the hippocampus), the growth of capillaries, increasing the amount of blood flow, tissue oxygenation, neurotropin production, neurotransmitters, the development of neural connections, and the volume density of nerve and brain tissue, which results in improved cognitive function.[15]Brain plasticity is influenced by physical activity through the increasing blood flow to the brain, maximization of the use of oxygen and glucose by the brain, acceleration of the disposal of chemical substances that are not useful to maintain the balance of blood flow, and an upsurge in the antioxidants capabilities to scavenge and neutralize free radicals. Regular physical activity can also increase the synthesis of nerve growth factors (NGF) and stimulate neurogenesis improving connections between synapses and increasing the capacity of nerve cells.[3]One out of three T2DM patients with mild cognitive impairment who received the poco-poco dance intervention 30 minutes twice a week for 12 weeks, will experience an improvement in their executive functions, or in other words, a worsening of executive function will be prevented in one person.

Conclusion

The biweekly poco-poco dance for 30 minutes for 12 weeks in T2DM patients with mild cognitive impairment is able to:Improve their executive functions up to 37.5%.Improve the neuronal functions and plasticity at the prefrontal and left parietal cortexes, and the right hippocampus. This intervention is capable of activating the neurons in the inactive left hemisphere.Improve glycemic control (HcA1c), lipid profiles (LDL, triglyceride, and total cholesterol levels), and reduce the oxidative stress (F_2 Isoprostan).

Funding

Personal from Ria Maria Theresa.

Recommendations

Dancing the poco-poco is an easy, inexpensive, and practical method in the community to preserve or improve the executive functions in order to maintain independence and quality of life of the pre-elderly and elderly. Further research on other traditional dances from other regions that is similar to poco- poco needs to be developed to see its impact against neuroplasticity. Further research on the biomolecular improvement mechanisms of the neuronal plasticity is necessary (glycemic control, lipid profile, and oxidative stress).

References

1. Wild S. Global Prevalence of Diabetes Estimates for Year 200 and Projection for 2030.
2. Diabetes care 2004; 27: 1047-53.
3. Martina WSN. Deteksi Dini Hendaya Kognitif Non Demensia Pada Penyandang Diabetes Melitus Tipe 2 [disertasi]. Jakarta: Universitas Indonesia; 2007.
4. Sudoyo AW, Setioyohadi B, Alwi I, dkk. Buku Ajar Ilmu Penyakit Dalam. Edisi V. Interna Publishing. Jakarta. 2009; 1875-1928.
5. Pekerti R. Neurosains Menuju Seni Tari Berbasis Kreativitas Membentuk Kecerdasan Budaya Baru. Maret 2012.
6. Kramer AF, Erickson KI, and Colcombe JA.Exercise, cognition, and the aging brain. J Appl Physiol. 2006; 101: 1237-42.
7. Lambourne K, Audiffren M, Tomporowski PD. Effects of acute exercise on sensory and executive processing tasks. Med. Sci. Sports Exerc. Medscape.2010; 42(7): 1396-1402.
8. Scherder EJ, Van Paasschen. Physical activity and executive function in the elderly with mild cognitive impairment.Center of Human Movement Sciences. Aging Men Health. 2005; 9(3): 272-80.
9. Blassing B. Expertise and Cognitive Structure in Dance. Blassing B, Puttke D, Schack T. editors. The Neurocognition of Dance, Mind, Movement and Motor Skills. New York. Psychology Press: 2010. p.75-95.
10. Schack T. Building Blocks and Architecture of Dance. Blassing B, Puttke D, Schack T. editors. The Neurocognition of Dance, Mind, Movement and Motor Skills. New York. Psychology Press: 2010. p.11-35.
11. Chaiklin S, Wengrover H. The Art and Science of Dance/Movement Therapy: Life Is Dance. New York. 2009.
12. Bosser W, Heuvelen, Blankevoort. Effects of a six weeks combined aerobic and strength training intervension on cognition and phisical functioning in older people with dementia. [Thesis]. University Groningen. June 2009.
13. Park SJ, Kim SH,Song SW. Effect of dance exercise on cognitive function in elderly patients with metabolic. J. Sports Sci. Med. 2011; 10: 671-8.
14. Ratey JJ, Loehr JE. The positive impact of physical activity on cognition during adulthood: a review of underlying mechanisms, evidence and recommendations. 2011;22(2):171-85. doi: 10.1515/RNS.2011.017.
15. Erickson, Voss, Prakash, et al. Exercise training increases size of hippocampus and improves memory. PNAS. 2011: 108(7). 3017-22.
16. Swain RA, Berggren KL, Kerr AL. On Aerobic Exercise and Behavioral and Neural Plasticity. Brain Sci. 2012, 2, 709-44; doi:10.3390/brainsci2040709.