



ISSN: 0976-3376

Available Online at <http://www.journalajst.com>

ASIAN JOURNAL OF
SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 10, Issue, 01, pp.9326-9330, January, 2019

RESEARCH ARTICLE

POSTURAL EQUILIBRIUM AND MECHANICAL EXERCISE PROGRAM IN SECONDARY SCHOOL STUDENTS WITH TYPE 1 DIABETES IN TANTA CITY

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ARTICLE INFO

Article History:

Received 19th October, 2018
Received in revised form
15th November, 2018
Accepted 20th December, 2018
Published online 30th January, 2019

Key words:

Equilibrium; Mechanical exercise;
Secondary school students; type 1
diabetes; Biodex Balance System.

ABSTRACT

The aim of our study was to assess the postural equilibrium in secondary school students with type 1 diabetes in Tanta city pre and post equilibrium training program. The age of participated secondary school students are seventeen years old with chronicity of diabetes nearly ten years. Their body mass index between 15-18 kg and m². Thirty secondary school students participated in this study divided into two equal groups, the first group (control) consisted of fifteen normal secondary school students on the other hand the second group (study) consisted of fifteen secondary school students with type 1 diabetes. Assessment of equilibrium and equilibrium training program was done on Biodex balance system at stability level eight according to pilot study done before the study. The equilibrium training program and mechanical exercise was conducted in the morning in room equipped with treadmills, stretching mats and biodex Balance System achieved for period of three month (thirty six sessions with frequency day after day) then reassessment was done again at stability level eight. The dynamic equilibrium test pre and post treatment program including anteroposterior stability index, mediolateral stability index and overall stability index. Before equilibrium training program, there was statistically significant difference between study and control group regarding stability indices (OA, AP and ML) at stability level-8 ($P < 0.05$) which indicating that decrease of equilibrium control in secondary school students with type 1 diabetes. After equilibrium training program, there was no statistically significant difference between study and control group regarding stability indices (OA, AP and ML) at stability level-8 ($P > 0.05$) which indicating that improvement of equilibrium control in secondary school students with type 1 diabetes. **Conclusion:** It could be concluded that, before equilibrium training program, there is decrease in equilibrium parameters including (OA, AP and ML indices) at level eight of stability in secondary school students with type 1 diabetes compared with normal students. On the other hand, after diet control, mechanical aerobic exercise, insulin therapy and equilibrium training program there is improvement of equilibrium control in secondary school students with type 1 diabetes.

Citation: Mohamed N. AlKhouli, Anees S. Ghait, Amr A. Abogazy and ElSayed A Eid, 2019. "Postural equilibrium and mechanical exercise program in secondary school students with type 1 diabetes in tanta city", *Asian Journal of Science and Technology*, 10, (01), 9326-9330.

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INTRODUCTION

Our bodies turn most of the food we eat into glucose (sugar). Glucose is then transported around the body where it is used for energy. The pancreas produces a hormone called insulin that controls this process (Shumway and Woollacott, 2001). Insulin helps transfer glucose in the blood into the cells of the body, thereby keeping the amount of glucose in the blood at a safe level. When diabetes occurs, the body either doesn't make enough insulin, or the insulin produced doesn't work the way it should.

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When this happens, the glucose levels are not controlled properly and this causes the amount of glucose in the blood to rise. (Nichols, 2001) (Khan *et al.*, 2001). Diabetes mellitus (DM), commonly referred to as diabetes, is a group of metabolic disorders in which there are high blood sugar levels over a prolonged period. Symptoms of high blood sugar include frequent urination, increased thirst, and increased hunger. If left untreated, diabetes can cause many complications. Diabetes is due to either the pancreas not producing enough insulin or the cells of the body not responding properly to the insulin produced. (Aaron *et al.*, 2003). There are three main types of diabetes mellitus. Type 1 diabetes: usually develops in children, teenagers, or young adults. In this type of diabetes, the pancreas stops making

insulin (Skeleton D and Beyer N). Type 1 diabetes is a chronic autoimmune disease in the vast majority and accounts for over 90 percent of childhood and adolescent diabetes in Australia. T-cell mediated destruction of the pancreatic beta cells leads to insulin deficiency (Rubenstein, 2004) (Sacks *et al.*, 2002). Type 2 diabetes: is the most common form of diabetes and can develop at any age. In this type of diabetes, the body does not make enough insulin and any insulin that the body does makes does not work properly. Gestational diabetes: can occur during the late stages of pregnancy but usually goes away after the baby is born. Women who have had this type of diabetes are more likely to get type 2 diabetes later in life (Dellon, 2004). Diabetes complications affect all body systems including the neuromuscular system in form of sensory, motor and autonomic neuropathies. Motor neuropathy is characterized by muscle atrophy, changes in gait, new pressure points and ulceration in foot. Sensory neuropathy is characterized by loss of sensation, bone changes, deformed foot, and painless trauma. Autonomic neuropathy is characterized by decrease in perspiration, dry skin cracks fissures, infection, gangrene and amputation (Gardener, 2001) (Paolo, 2001).

Equilibrium is defined as the process of maintaining the center of mass (COM) within the body's base of support (BOS). To maintain erect bipedal stance, the central and peripheral components of the nervous system are interacting to control body alignment and the center of mass (COM) over the base of support (BOS). Peripheral components in balance include somatosensory, visual, and vestibular systems. The (CNS) central nervous system incorporates the peripheral inputs from these systems and selects the most appropriate muscular responses to control body posture over the (BOS) (Rozzi *et al.*, 2001). Equilibrium controlled on the basis of afferent information from somatosensory, visual and vestibular systems. The first two systems are affected in the presence of diabetes and also participate in increasing the risk of falling among this population (Hess *et al.*, 2006).

Type 1 diabetes can develop nerve problems at any time, but significant clinical neuropathy can develop within the first ten years after receiving diabetes diagnosis so about 60% of people with diabetes have some form of neuropathy (Nakamura *et al.*, 2001). The aim of this study was to assess postural equilibrium in secondary school students with type 1 diabetes in Tanta city pre and post equilibrium training program. The age of participated secondary school students are seventeen years old with chronicity of diabetes nearly ten years. Their body mass index between 15-18 kg/m².

MATERIAL AND METHODS

Patients population: Thirty secondary school students with type 1 diabetes participated in this study divided into two equal groups, the first group (control) consisted of fifteen normal secondary school students on the other hand the second group (study) consisted of fifteen secondary school students with type 1 diabetes. Assessment and equilibrium training program was done by Biodex balance system via the dynamic balance test which including anteroposterior, mediolateral and overall stability index at stability level eight. Secondary school students with type 1 diabetes participated in this study taking diet therapy. Insulin therapy, mechanical exercise and equilibrium training program for 12 weeks. The age of

participated secondary school students are seventeen years old with chronicity of diabetes nearly ten years. Their body mass index between 15-18 kg/m².

Equipment

Treadmill: The Ergocard System (Ergocard central unit, Medcard PC-ECG recorder and Expair software). The purpose is to help in using and putting Medi-soft equipment into service. It describes the operating procedures to a level of detail that would satisfy most clinical uses. All the necessary measurements must be taken in order to ensure safe use of the equipment. This document is based on the last version (1.29X) of the Expair software. With a view to constantly improving its products, Medi-soft S.A. reserves the right to modify the software or issue updates without prior notice. Mechanical exercise was conducted in the morning in room equipped with treadmills and stretching mats. The treatment session divided as follows: 1) warm-up (5 minutes): stretching exercises; 2) main exercises (30 minutes): walking on the treadmill, and 3) back to relaxation (10 minutes): stretching and relaxation. At the beginning of the program, intensity of the physical exercise was kept at 60% of the maximum heart rate (max HR) predicted for both groups, and gradually increased until reaching the 70% of max HR target (Fox *et al.*, 1991).

Biodex balance system: It is a balance screening and training tool. It consists of a movable balance platform, which provides up to 20 degree of surface tilt in a 360 degree range (Biodex medical system Inc, Shirley New York, U.S.A.). The stability levels available by the system range from a completely firm surface (stability level eight) to a very unstable surface (stability level 1) (Rozzi *et al.*, 2001).

The study was done in biomechanics lab at faculty of physical Therapy, Delta University for Science & Technology.

The dynamic balance test parameters include

- AP stability index: represent the patient's ability to control balance in front to back directions. High values represent less stability in all indices of the system.
- ML stability index: represent the patient's ability to control balance from side to side.
- OA stability index: represent the patient's ability to control balance in all direction.

Equilibrium assessment and training program by Biodex Balance system was performed in standing position. The subject was instructed to focus on the visually feedback screen directly in front of him and attempt to maintain the cursor at the center of the screen while standing on the unstable platform (stability level eight). The equilibrium training program achieved for period of three month (with frequency of session day after day) then reassessment was done again at stability level eight.

RESULTS

Comparing between the mean values of stability indices (OA, AP and ML) at stability level-eight. There was statistical significant difference between both groups ($P < 0.05$)

Table 1. Stability indices for the normal control group at stability level eight

Level eight	
Stability index (SI)	X ± SD
Overall stability	2.46 ± 1.11
Anteroposterior stability	2.63 ± 1.12
Mediolateral stability	2.15 ± 0.61

Overall stability index: The mean value of OA index of the control group at stability level eight was 2.46 ± 1.11 .

Anteroposterior stability index: The mean value of AP stability of the control group at stability level eight was 2.63 ± 1.12 .

Mediolateral stability index: The mean value of ML stability of the control group at stability level eight was 2.15 ± 0.61 .

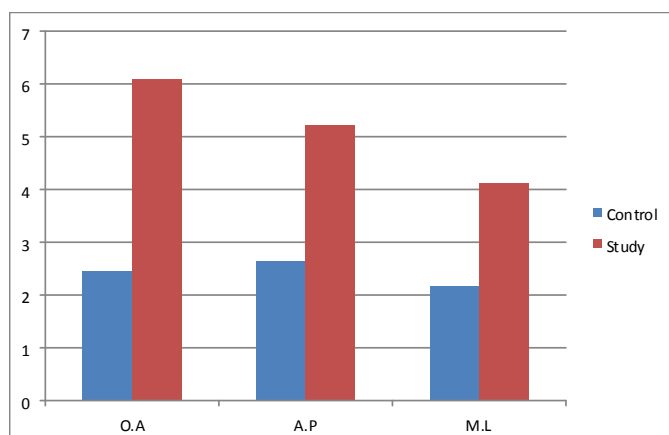
Table 2. Stability indices for the study group at stability level eight

Level eight	
Stability index (SI)	X ± SD
Overall stability	6.12 ± 1.24
Anteroposterior stability	5.22 ± 1.33
Mediolateral stability	4.13 ± 1.16

Overall stability index: The mean value of OA index of the study group before equilibrium training program at stability level eight was 6.12 ± 1.24 . **Anteroposterior stability index:** The mean value of AP stability of the study group before equilibrium training program at stability level eight was 5.22 ± 1.33 . **Mediolateral stability index:** The mean value of ML stability of the study group before equilibrium training program at stability level eight was 4.13 ± 1.16 .

Table 3. Comparison between stability indices for the study group and the control group before equilibrium training program at stability level eight

Stability Index (SI)		X ±SD	t value	Sign.
Overall (O.A)	Study group	6.12 ± 1.24	0.00	P<0.05
	Control group	2.46 ± 1.11		
Anteroposterior (A.P)	Study group	5.22 ± 1.33	0.00	P<0.05
	Control group	2.63 ± 1.12		
Mediolateral (M.L)	Study group	4.13 ± 1.16	0.00	P<0.05
	Control group	2.15 ± 0.61		



OA index: Mean values of OA index before equilibrium training program for study group and control group at stability

level eight were 6.12 ± 1.24 and 2.46 ± 1.11 respectively showed high significant differences ($P < 0.05$).

AP stability: Mean values of AP stability before equilibrium training program for the study group and the control group at stability level eight were 5.22 ± 1.33 and 2.63 ± 1.12 respectively showed high significant differences ($P < 0.05$).

ML stability: Mean values of ML stability before equilibrium training program for the study group and the control group at stability level eight were 4.13 ± 1.16 and 2.15 ± 0.61 respectively, showed high significant differences ($P < 0.05$).

Table 4. Comparison between stability indices for the study group and the control group after equilibrium training program at stability level eight

Stability Index (SI)		X ±SD	t value	Sign.
Overall	Study group	2.99 ± 1.11	0.00	P>0.05
	Control group	2.46 ± 1.11		
Anteroposterior	Study group	2.88 ± 1.16	0.00	P>0.05
	Control group	2.63 ± 1.12		
Mediolateral	Study group	2.44 ± 1.19	0.00	P>0.05
	Control group	2.15 ± 0.61		

OA index: Mean values of OA index after equilibrium training program for study group and control group at stability level eight were 2.99 ± 1.11 and 2.46 ± 1.11 respectively showed no significant differences ($P > 0.05$).

AP stability: Mean values of AP stability after equilibrium training program for the study group and the control group at stability level eight were 2.88 ± 1.16 and 2.63 ± 1.12 respectively showed no significant differences ($P > 0.05$).

ML stability: Mean values of ML stability after equilibrium training program for the study group and the control group at stability level eight were 2.44 ± 1.19 and 2.15 ± 0.61 respectively, showed no significant differences ($P > 0.05$).

DISCUSSION

The equilibrium training program and mechanical exercise was conducted in the morning in room equipped with treadmills, stretching mats and biodex Balance System achieved for period of three month (thirty six sessions with frequency day after day) then reassessment was done again at stability level eight. The dynamic equilibrium test pre and post treatment program for period of three month including anteroposterior stability index, mediolateral stability index and overall stability index. Before equilibrium training program, there was statistically significant difference between study and control group regarding stability indices (OA, AP and ML) at stability level-8 ($P < 0.05$) which indicating that decrease of equilibrium control in secondary school students with type 1 diabetes. After equilibrium training program and mechanical exercise, there was no statistically significant difference between study and control group regarding stability indices (OA, AP and ML) at stability level-8 ($P > 0.05$) which indicating that improvement of equilibrium control in secondary school students with type 1 diabetes. The elevated stability indices of equilibrium at stability level eight in the secondary school students with type 1 diabetes could be attributed to muscles weakness either in progravity or antigravity muscles of lower

limb especially the foot and ankle. In addition to limited joint mobility (Gutierrez *et al.*, 2001). Limited joint mobility is a common complication affecting about 30% of type 1 diabetes in adolescence and at the same time associated with microvascular complications. Limited joint mobility in the feet may lead to secondary foot problems associated with abnormal pressure areas (Nichols, 2001). Hyperglycemia increases non enzymatic glycosylation of collagen which cause abnormal cross linking and subsequent stiffness of the soft tissue which lead to limited ankle dorsiflexion and decrease the mobility of the first ray and also leads to contracture of tendon Achilles (Zheng *et al.*, 2000). On the other hand disturbance of equilibrium in secondary school students with type 1 diabetes could be attributed to inability of those subjects to activate distal muscles (ankle synergy) quickly enough to recover stability at the maximum disturbance produced at level eight due to timing problem.

Poor postural control of secondary school students with type 1 diabetes could be attributed also to muscle weakness especially of the foot and ankle muscles. As diabetes affect muscle strength and decrease muscle power required to produce joint stability and adequate reactions (Gutierrez *et al.*, 2001). Endurance which is the capacity of muscle to contract continuously at sub maximal level decrease by diabetes which lead to smaller size of muscles and this reduction in muscle mass is greater in the lower extremity than the upper extremity. The muscle cell die and they are replaced by connective tissue and fat (Osullivan, 2002). Diabetes affects the amount of force that the muscles produce and also affect strength of skeletal muscle. The lower extremity strength can be reduced by as much as 40% between age 30 and 80 years (Opara, 2002). Deficits in postural control of secondary school students with type 1 diabetes during equilibrium test might be due to distorted proprioception of the lower limb, decline in the muscle strength of the lower limb specially foot and ankle, in addition to decline in the muscle endurance that may affect their ability to maintain balance. The results of this study supported by the results of another study done by Cooppan, 1996 who explained that; good glycemic control require good diet therapy, insulin injection and aerobic exercise at least for 45 minutes three time every week. Also the gained results were on line with the work of Nathan *et al.* 2005 who studied the effects of aerobic exercise on glycosylated hemoglobin in adolescents with type 1 DM and proved that good glycemic control require exercise therapy, balance exercise plus medication and diet therapy.

The benefits of regular physical exercise for secondary school students with type 1 diabetes include improved insulin sensitivity, weight management, musculoskeletal benefits, functional movement development, psychological wellbeing, social interaction and cardiovascular fitness (WHO, 2003 and National Institute of Clinical Excellence, 2004). Regular physical exercise in children and adolescents with type 1 diabetes can improve aerobic capacity (Roberts and Jones, 2002) and muscle strength, however the reported effect of physical activity on glycemic control (measured by HbA1c) varies (Mosher *et al.*, 1998). One small RCT (n=9) showed an improvement in HbA1c with regular sustained physical activity compared with 30 minutes vigorous physical activity three times per week (HbA1c 11.3% versus 13.3%); however this group of patients was in very poor metabolic control (Compaigne *et al.*, 1984). Another small study (n=12) found

that the HbA1c in both 'poorly' (HbA1c >9%) and 'well' controlled (HbA1c <9%) diabetic patients was not affected by 12 weeks of supervised training. During the ensuing 12 week period of unsupervised training, any improvement in aerobic capacity decreased to pre-training levels suggesting that compliance with unsupervised training was poor (Roberts and Jones, 2002). In a third study of a 12 week physical activity program, the HbA1c of subjects with type 1 diabetes was reduced (only in those with poor glycemic control) by 1% (p <.05) (Mosher *et al.*, 1998). It could be concluded that, before postural equilibrium and mechanical exercise program, there is decrease in equilibrium parameters including (OA, AP and ML indices) at level eight of stability in secondary school students with type 1 diabetes compared with normal students. On the other hand, after diet control, mechanical aerobic exercise, insulin therapy and equilibrium training program there is improvement of equilibrium control in secondary school students with type 1 diabetes.

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