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Effect of Circuit Weight Training on Balance in Type 2 Diabetic Polyneuropathy: A follow up Randomized Controlled Trial

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ABSTRACT

Background: Polyneuropathy is a common problem for people with diabetes, leading to pain and impaired sensation and movement in the limbs, and often experience balance disorder. Physical activity has been proven as a beneficial intervention for prevention and treatment of balance disorder. **Objective**: The purpose of this study was to examine the effect of circuit weight training on balance in type 2 diabetic polyneuropathy on short-run basis (after 8 training weeks) and on long-run basis (follow up; 4 weeks post training cessation). **Material and Methods:** Forty type 2 diabetic patients with polyneuropathy participated in the study (27 men, 13 women), their ages ranged from 55-65 years were randomly assigned to two groups equal in number (n= 20). Group (A) study group received circuit weight training (CWT) and training by treadmill and Group (B) control group received training by treadmill. Exercise training was performed 30 minutes, three times per week for circuit weight training and control (treadmill) groups for 8 weeks. Two parameters of balance index. Antero-posterior stability index and medio-lateral stability index were evaluated pre-training, after 2 months of training (post-training (1) and 1 month post training cessation (post-training (2), **Results:;** Circuit weight training seems to yield more beneficially and statistically significant effect on balance index more than treadmill training on long run basis. **Conclusions:** Participation in circuit weight training is more effective and alternative to aerobic training in improving balance index in type 2 diabetic polyneuropathy for more extended period of time.

Key words: Type 2 diabetes mellitus, circuit weight training, balance diabetic polyneuropathy.

INTRODUCTION

DIABETES is a global endemic with rapidly growing prevalence in both developing and developed countries 5. Diabetes is associated with premature mortality, predominantly through atherosclerotic vascular disease, microvascular complications which affect small blood vessels in the eye, kidney and nerves, are associated with considerable morbidity [16].

Diabetic neuropathies are a disabling complication of diabetes mellitus. The most common form is a chronic distal symmetric sensorimotor polyneuropathy [diabetic polyneuropathy (DPN)] [12].

In diabetic neuropathic patients, postural sway is increased, especially with the eyes closed. Peripheral neuropathy caused by diabetes causes significantly impaired sensation in the feet, reducing patients' ability to control their balance properly during daily activities. Poor balance can be due to proprioception impairment. Balance problems are also caused by movement-strategy impairment, biomechanical structural disorders, and disorientation [7].

People with diabetic polyneuropathy (DPN) have balance disorders even with open eyes, making them vulnerable to falls [20]. However, exercise may positively influence the pathological factors associated with neuropathy by promoting micro vascular dilatation, reducing oxidative stress. [23, 14, & 17].

Circuit weight training (CWT) has been shown to be beneficial in improving many factors associated with good health. These factors include increased function and prevention of falls, decreased lipid profiles, improved glucose tolerance and insulin sensitivity, increased lean body mass, increased basal metabolic rate (weight control), body fat percent and at last improved quality of life [3].

A combination of aerobic and resistance exercise improves physical fitness, glycemic control and insulin sensitivity in people with diabetes [32, 6, 22]. Furthermore; whereas the therapeutic benefits of exercise have been studied extensively in middle-aged type 2 diabetic patients 8, little is known about the impact of exercise training in older people with this condition [9]. Similar to aerobic exercise, resistance training has been demonstrated to be safe and efficacious for the elderly [33], has been recognized as a useful therapeutic tool for the treatment of a number of chronic diseases [13], and in recent years resistance training has been gaining wide acceptance as an important strategy in the treatment of diabetes [35].

Although there has been increasing interest in the last decade in the role of resistance exercise training in the management of diabetes [35]; data regarding the effect of resistance training in the treatment of type 2 diabetes (T2D) has conflicting results, many studies suggest the beneficial of its effect [28], and others found no effect [10].

As our first step in the treatment of inactive individuals with type 2 diabetes (T2D) is to encourage them to be active; resistance training may be a more attractive option than aerobic activities, so the purpose of this study was to explore the effect of circuit weight training on balance in type 2 diabetic polyneuropathy on short-run basis (after 8 training weeks) and on long-run basis (follow up; 4 weeks post training cessation).

METHODOLOGY

Subjects

Forty diabetic neuropathic patients, age ranged from 55-65 years old, were screened and selected randomly to be enrolled into this 8-week blinded randomized controlled trial. They were recruited from outpatient clinics of the Faculty of Physical Therapy; Cairo University to participate in this study. This study was approved by the ethics committee of the Faculty of Physical Therapy, Cairo University.

The forty patients with type 2 diabetes mellitus of both sexes (27 men and 13 women) fulfilled the inclusion criteria of the study, had no exclusion criteria, provided informed consent form giving agreement to participation and publication of the results of the study, they underwent the initial evaluation, completed the training course and the final statistical analysis.

Inclusion criteria were as follows: established type 2 diabetes for more than 5 years duration, neuropathic patients, treatment only with oral hypoglycemic agents (not taking insulin), an inactive previous lifestyle for at least previous 6 months, fasting blood sugar test result (>110 mg/dl).

Exclusion criteria were BMI ≥ 40, age over 65 or less than 55 years, smoking, severe retinopathy, visual problems not corrected, nephropathy patients who had scars under their feet, history of serious cerebrovascular or cardiovascular diseases, and severe musculoskeletal problems restricting physical activity.

Initial medical screening was performed for each patient by the physician; and clinical history was documented for all participants. Study protocol and objectives of the study were thoroughly explained to all participants who were asked to maintain their pharmacological treatment, regular diet, normal daily activities and lifestyle throughout the study.

To avoid a type II error, a preliminary power analysis (power (1-β error probability)) = 0.85, α = 0.01, effect size = 0.5) determined a sample size of 40 for this study. This effect size was chosen because it yielded a realistic sample size 37.

To avoid bias; patients' random assignments were performed through 2 stages, first, colleague physical therapists who were working in the outpatient clinics of the Faculty of Physical Therapy; Cairo University reported all patients who fulfilled the inclusion criteria of the study and had no exclusion criteria. Second, after medical counseling; patients are randomly assigned into either Group (A) study group received circuit weight training (CWT) and Group (B) control group received training by treadmill. It was done through opening an opaque envelope prepared by an independent person with random number generation.

Patients were randomly assigned to one of two groups; Group (A) who received 8-weeks circuit weight training and Group (B) control group received training by treadmill well designed aerobic exercise training. The exercise program was determined in accordance with the American College of Sport Medicine (ACSM) guidelines and was conducted during July 2013 to December 2013.

Outcome measures:

Both groups underwent an identical battery of tests; baseline (Pre-training), after exercise training program; 2 months (Post-training-1) and 1-month post exercise training cessation (Post-training-2). The evaluated parameter include antero-posterior stability index (ASI) and medio-lateral stability index (MSI).

There were three measurement points throughout the study: pre-training, after two months training (Post-training-1) and after 4-weeks post-training cessation (Post-training-2). The assessors were initially blinded to the participants’ treatment assignments.

Initially, data concerning the subjects’ characteristics was collected in the first session including resting heart rate (beats/ minute),resting respiratory rate (cycle/ minute) is measured by counting the number of breaths a person takes in a one-minute period. Since many factors can affect the results, understanding how to take an accurate measurement is very important.

The rate should be measured at rest, not after someone has been up and walking about. Being aware that your breaths are being counted can make the results inaccurate, as people often alter the way they breathe if they know it's being monitored. The authors are skilled at overcoming this problem by discretely counting respirations, watching the number of times your chest rises and falls, often while pretending to take your pulse, they were measured at three time points using standard laboratory scales. Additionally; heart rate and blood pressure were measured during the sessions to exclude any signs or symptoms that may interfere with the continuity of the study. Blood sugar levels were repeatedly monitored using a glucometer. After seated comfortably for about 5 minutes; blood pressure was measured on the left arm by auscultatory method using standard mercury sphygmomanometer. Weight in (kg) was measured to the nearest 0.1 kg, using standard weight scale.

Each weighing scale was standardized every day with a weight of 50 kg. Height was measured to the nearest 0.1 cm with the subject standing in an erect position against a vertical scale of portable stadiometer and with the head positioned so that the top of the external auditory meatus was in level with the inferior margin of the bony orbit. BMI (kg/m2) was calculated as weight in kilograms divided by squared height in meter to exclude BMI≥ 40 19.

The Biodex Balance System

The Biodex balance system (BBS) is a simple, efficient balance screening and training tool. In this study, the Biodex balance system was used for assessment of dynamic balance. The study was conducted in the balance laboratory in the Faculty of Physical Therapy, Cairo Univeristy. BBS helps to test and improve patients balance through use of a computerized (wobble board). Patients must use the feet and ankles to control the screen cursor while the wobble board becomes unsteady. The computer analyzes the patient movements and determines in which directions the patient design to move or is having difficulty moving. The BBS is extremely effective, providing instantaneous feed back that makes it easy for patients to relate to and produce specified movement pattern.

The BBS consists of a display screen, support handle rails, a platform and a printer.

The dynamic balance test parameters include:

The degree of surface instability is controlled by a microprocessor based actuator; the test consists of recording the patient ability to control variance from a perfectly balanced position. The measures of postural stability include stability index scores; antero–posterior (AP), medio–lateral (ML).

These indices are standard deviations assessing fluctuations around the zero point (horizontal) rather than around a group mean. The APSI and MLSI assess the fluctuations from the horizontal along the AP and ML axes of the BSS. The stability index scores are calculated from the degree of tilt from the horizontal and are averaged over the 3 test evaluations. A high number indicates substantial movement away from the participant's center of balance while a low number indicates minimal movement during the test.

Dynamic balance testing passed by three steps; preparatory, centering, and recording steps.

1- The preparatory step:

- The participant's personal data together with the testing duration, patient’s weight and height and stability level of the platform of the BBS were introduced to the software of the device.
- Every participant stood on the platform of the BBS in an ideal posture (standing on both feet keeping the chin in, the shoulders leveled and retracted, the back straight and the knees drawn backwards). This ideal posture was to be kept throughout the whole testing duration.
- The support handle rails and display screen were adjusted according to the participant's height.

2- The centering step:

- This step involved recording the participant's feet coordinates.
- Each participant was asked to step on the platform of the BBS which was locked (kept immovable) and assume a comfortable position while grasping the support handle rails by both hands.
- The platform was then unlocked. When the platform was released, the participant was asked to position himself/herself so that he/she was able to keep the cursor that was displayed on the display screen of the platform, centered in the displayed circle. Once centering was achieved and the cursor was in the center of the display screen, each participant was instructed to maintain the feet positions constant till the end of the test and the platform was locked to record the feet positions and coordinates.
- Feet positions′ coordinates were determined by identifying the location of the center of the back of each heel in relation to the X and Y coordinates. The feet angles were determined by identifying the lines on the platform that are parallel to the 2 nd metatarsal bone of each foot. Then, the feet angles and heels′ coordinates for each participant were introduced to the software of the BBS. The aim of the centering step is to position the center of gravity (COG) over the point of the vertical ground reaction force vector (VGRF).

3- The recording step:

- Two-legged stance for both groups was assessed, over a period of 20 seconds. The platform was changed to an unstable state and the participant was instructed to focus on the display screen and attempt to maintain the cursor in the middle of the circle shown on the display screen while he/she was standing without grasping the support handle rails and both arms kept beside the body.
- Each participant was trained for 1 min to be adapted to the testing procedures. Three practice trials were performed to

reduce any learning effects. Finally, three test evaluations were performed with a rest time of 10 s between each two consecutive tests and the mean of the three readings was recorded.

- At the end of each test trial, a print out report was obtained. This report included the APSI, and MLSI.

- The APSI: This represents the participant's ability to control balance in an antero-posterior direction.

- The MLSI: This represents the participant's ability to control balance in a side to side direction.

- Dynamic balance was tested for both the groups three times; before, after a 4 week and after another 4 weeks from treatment period cessation.

Exercise training protocols

Sufficient warm up and cool down (about 10-15 minutes) in the form of stretching of major muscles groups, flexibility movements, active movements of limbs, breathing exercises and walking at low intensity (50% of maximum heart rate) 11 was performed before and after either circuit weight training or aerobic training sessions. Also sufficient time was consumed in familiarizing the participants in circuit weight training group with the resistance training machines, through doing 1 set of each exercise on different weight machines that were repeated 8-10 times. Also, sufficient time was consumed in familiarizing the participants in aerobic training group with the utilized treadmill and safety measures.

For both groups; closely supervised exercise training was regularly held on a frequency of three sessions per week. Participants were encouraged to have sweet eatable or drinkable things during training to compensate for probably occurring hypoglycemic episodes. Also they were advised not to eat heavy meals at least 2 hours before training.

Resistance circuit weight training programme

The following exercises (stations) were performed: bench press, seated row, shoulder press, chest press, lateral pull down, abdominal crunches, leg press, leg extension, triceps pushdown and seated bicep curls.

Twenty patients participated in a CWT exercises program performed 30 minutes, 3 times per week for 12 weeks. Closely supervised training techniques were performed for participants of this group after proper warm up to minimize the risk of musculoskeletal injuries. The program started and progressed gradually in frequency and intensity. The protocol was started twice per week sessions during the first month and was increased to 3 non-consecutive days' sessions per week on the following 2nd months 11, 38.

The intensity progress for circuit weight training group followed the stepwise manner in which there was a gradual increase by 2.5% of one-repetition maximum (1RM) every 2 weeks. Moderate resistance was used in which 60 -65% of 1RM was used during the first month, and then the intensity was increased to be 70-75% 1RM in the second month. The training program started with 1-2 sets of 10 repetitions of 10 different exercises for upper and lower body during the first month then the program was increased to be 3 sets of the 10 repetitions of 10 different exercises (stations) for upper and lower body during the second month. Circuit weight training exercises were performed with a 90- 120 seconds rest between each exercise group (station). Between each station the patient performed treadmill exercise, maintaining their rate of perceived exertion between 13 and 14 on Borge's score scale. 38 and 11.

Aerobic exercise programme

After warming up, participants of this group performed walking on treadmill activity using treadmill three times per week (on non-consecutive days). Time of exercise was increased from 20 minutes per session (at 60% of maximum heart rate) to 30 minutes (at 75% of maximum heart rate) per session 38. Aerobic exercise intensity was determined by the Karvonen formula in which Target Heart Rate = ((max HR − resting HR) × %intensity) + resting HR, where maximum heart rate = 220-age. 18. The participants of this group are directed to maintain their rate of perceived exertion between 13 and 14 on Borge's score scale. All forty subjects showed better adherence and acceptance to complete the training programs. No serious adverse effect was reported in either training groups.

Data Collection

Data from each patient in both groups (A&B) was taken concerning the following:

- For each group, study and control, Demographic and clinical characteristics of patients and balance parameters indices [Antero-posterior stability index (APSI) and medio-lateral stability index (MLSI)] pre and post training were collected.

Statistical Analysis

Descriptive statistics for all parameters in the form of:

- Mean of [Demographic and clinical characteristics, Antero-posterior stability index (APSI) and medio-lateral stability index (MLSI)].

- Standard error of [Demographic and clinical characteristics, Antero-posterior stability index (APSI) and medio-lateral stability index (MLSI)].

- Percentage of change in each parameter post training.

Inferential statistics in the form of:

- Paired t- test to examine the balance parameters indices [Antero-posterior stability index (APSI) and medio-lateral stability index (MLSI)] pre and post training in each group.
- Independent -t test to compare between the two groups (study and control), regarding the balance parameters indices [Antero-posterior stability index (APSI) and medio-lateral stability index (MLSI)] pre and post training
- The level of significance was set at $p \leq 0.05$.

RESULTS

This study was conducted to investigate the effect of circuit weight training on balance in type 2 diabetic polyneuropathy on short-run basis (8 weeks after training) and on long-run basis (follow up; 4 weeks post training cessation).

- Demographic and clinical characteristics of patients in both groups:

In the baseline (Pre-training) evaluation, results revealed that there were non-significant statistical differences between the two groups (circuit weight training group (A) and treadmill training group (B)) regarding the demographic characteristics including (age, height, weight, body mass index), duration of diabetes mellitus, and the glycosylated hemoglobin [HbA1c (%)], where (P > 0.05), as shown in Table 1.

Table 1: Demographic and clinical characteristics of patients in both groups (Mean ± SD).

Variables	Circuit weight training group (N=20)	Aerobic training group (N=20)	F value	t-value ☼
Age (year)	57.15 ± 2.32	58.25 ± 2.65	1.94	0.17 **
Height (m)	1.62 ± 0.04	1.64 ± 0.05	2.87	0.09 **
Weight (kg)	89.03 ± 5.84	89.11 ± 6.33	0.002	0.96 **
Body Mass Index (Kg /m^2)	33.99 ± 2.57	33.13 ± 2.11	1.35	0.25 **
Average duration of diabetes mellitus(years)	5.1 ± 0.66	4.9 ± 0.88	0.66	0.42**
HbA1c (%)	6.55 ± .84	7.21 ± .92	.55	.46**

☼= Level of significance at P<0.05 **= non-significant

- Baseline balance parameters APSI&MLSI in the two groups A&B:

The results of this study revealed that, there were no statistical significant differences between the two groups before treatment in the measured variables including the two parameters of balance index [Antero-posterior stability index (ASI) and medio-lateral stability index (MSI)], where t-value was [(1.170) & (1.347)] and P-value was [(0.286) & (0.253)] for APSI and MLSI respectively as shown in (Table 2). Results are illustrated in Fig.2.

Table 2: Baseline (pre-training) balance parameters (APSI&MLSI) in the two groups (A&B).

Variables	Baseline (Pre-training) evaluation			
	APSI		MLSI	
	Group(A)	Group(B)	Group(A)	Group(B)
Mean ± SE	3.33 ± .15	3.65 ± .20	2.61 ± .11	2.79 ± .13
t-value☼	1.17		1.35	
P-value	.29**		.25**	

APSI=Antero-posterior Stability Index MLSI=Medio-lateral Stability Index SE = Standard Error. ☼= Level of significance at P<0.05 **= non-significant

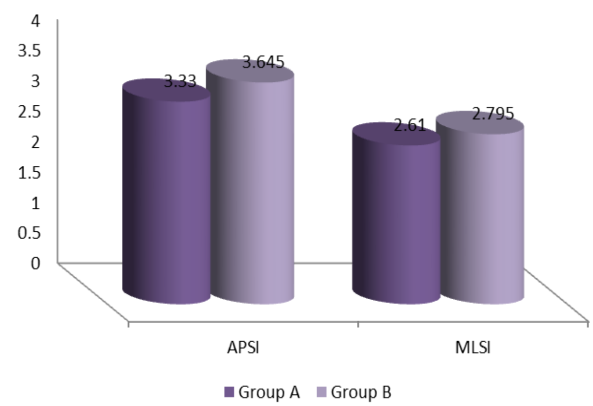


Fig.2 Baseline balances parameters APSI&MLSI in the two groups (A&B).

Balance parameters APSI&MLSI in the two groups A&B after Eight weeks of training:

- Antero-Posterior Stability Index (APSI)

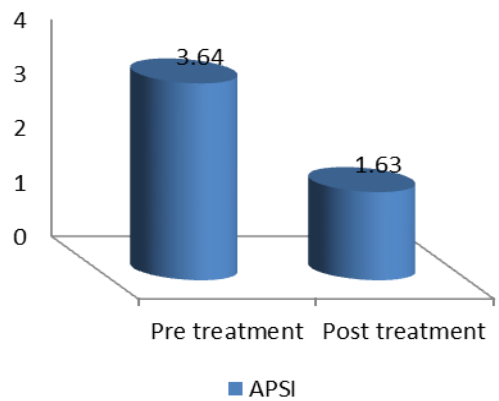
Table (3) shows that, there was a statistical significant difference in the two groups pre and post treatment I regarding the antero-posterior stability index.Concerning group (A), the mean value of pre treatment was (3.33± .154) and for post treatment I was (2.36±.139) with a percentage of change (29.12 %) where the t-value was (8.93) and p-value was (0.0002).

However, regarding group (B), the mean value of pre treatment was (3.64± .202) and for post treatment I was (1.63±.105) with a percentage of change (55.21%) where the t-value was (8.59) and p-value was (0.0001). Results are illustrated in Fig.3.

Table 3: Antero-posterior stability index in the two groups (A&B) after Eight weeks of training.

Groups / Variable	APSI			
	Group(A)		Group(B)	
	Pre treatment	Post treatment I	Pre treatment	Post treatment I
Mean ± SE	3.33 ± .15	2.36 ± .13	3.64 ± .20	1.63 ± .10
Percentage of Change	29.12 %		55.21%	
t-value☼	8.93		8.59	
P-value	0.0002*		0.0001*	

APSI=Antero-posterior Stability Index SE = Standard Error.
☼= Level of significance at P<0.05 * = significant



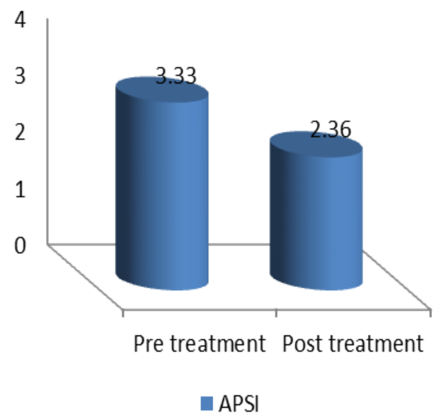


Fig.3 Antero-posterior Stability Index in group (A), study Antero-posterior Stability Index in group (B), control.

- Medio-Lateral Stability Index (MLSI)

Table (4) shows that there was a statistical significant difference in the two groups pre and post treatment I regarding the medio-lateral stability index. Concerning group (A), the mean value of pre treatment was (2.610± .115) and for post treatment I was (1.680±.087) with a percentage of change (35.63%) where the t-value was (7.488) and p-value was (0.0004).

However, regarding group (B), the mean value of pre treatment was (2.990± .199) and for post treatment I was (1.195±.089) with a percentage of change (60.03%) where the t-value was (7.780) and p-value was (0.0004). Results are illustrated in Fig.4.

Table 4: Medio-Lateral stability index in the two groups (A&B) after Eight weeks of training.

Groups / Variables	MLSI			
	Group(A)		Group(B)	
	Pre treatment	Post treatment I	Pre treatment	Post treatment I
Mean ± SE	2.61 ± .12	1.68 ± .09	2.99 ± .19	1.19 ± 08
Percentage of Change	35.63%		60.03%	
t-value☼	7.48		7.78	
P-value	0.0004*		0.0004*	

MLSI=Medio-Lateral Stability Index SE = Standard Error. ☼= Level of significance at P<0.05 * = significant

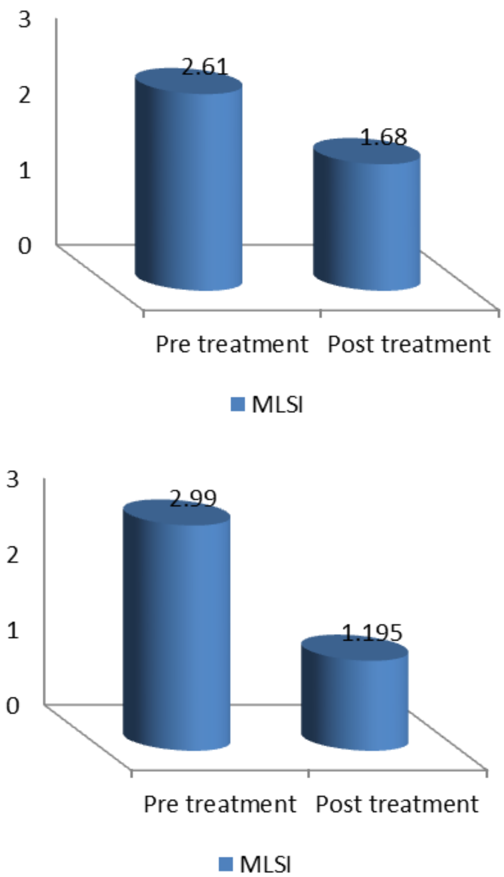


Fig.4 Medio-Lateral Stability Index in group (A), study Medio-Lateral Stability Index in group (B), control.

Balance parameters APSI&MLSI in the two groups A&B after four weeks of training cessation:

- Antero-Posterior Stability Index (APSI)

Table (5) shows that there was a statistical significant difference in group(A) for post treatment I and post treatment II regarding the antero-posterior stability index.While the mean value of post treatment I was (2.360± .139) and for post treatment II was (1.995±.115) with a percentage of change (15.46%) where the t-value was (5.075) and p-value was (0.0005).

However, regarding group (B), there was no significant difference between post treatment I and post treatment II regarding the antero-posterior stability index. While the mean value of post treatment I was (1.630± .105) and for post treatment II was (1.641±.104) with a percentage of change (-0.67%) where the t-value was (1.054) and p-value was (0.305) which is considered as a post cessation effect or decline in APSI. Results are illustrated in Fig.5.

Table 5: Antero-Posterior stability index in the two groups (A&B) after four weeks of training cessation.

Groups / Variables	APSI			
	Group(A)		Group(B)	
	Post treatment I	Post treatment II	Post treatment I	Post treatment II
Mean ±SE	2.36 ± .14	1.99 ± .12	1.63 ± .11	1.64 ± .10
Percentage of Change	15.46%		-0.67%	
t-value☼	5.08		1.05	
P-value	0.0005		0.305	

APSI=Antero-posterior Stability Index SE = Standard Error.
☼= Level of significance at P<0.05 * = significant

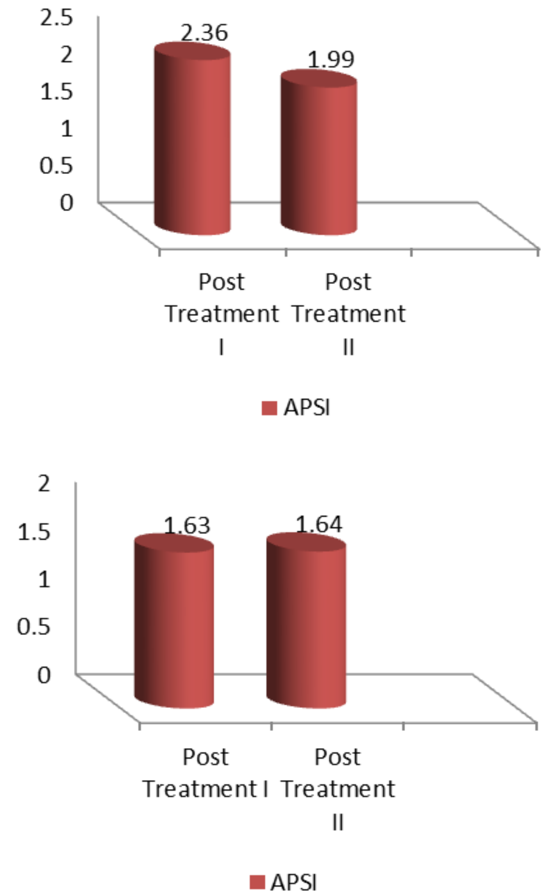


Fig.5 Antero-posterior Stability Index in group (A), study Antero-posterior Stability Index in group (B), control.

- Medio-Lateral Stability Index (MLSI)

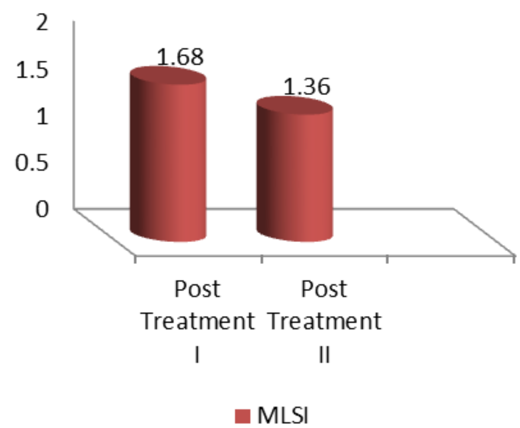
Table (6) shows that there was a statistical significant difference in group (A) for post treatment I and post treatment II regarding the medio-lateral stability index. While the mean value of post treatment I was (1.680± .0875) and for post treatment II was (1.365±.0898) with a percentage of change (18.75%) where the t-value was (5.294) and P-value was (0.0005).

However, regarding group (B), there was no significant difference between post treatment I and post treatment II regarding the medio-lateral stability index. While the mean value of post treatment I was (1.195±.089) and for post treatment II was (1.228±.081) with a percentage of change (-2.761%) where the t-value was (-1.965) and p-value was (0.064) which is considered as a post cessation effect or decline in MLSI. Results are illustrated in Fig.6.

Table 6: Medio-Lateral stability index in the two groups (A&B) after four weeks of training cessation.

Groups / Variables	MLSI			
	Group(A)		Group(B)	
	Post treatment I	Post treatment II	Post treatment I	Post treatment II
Mean ±SE	1.68 ±.09	1.36 ±.09	1.19 ±.09	1.23 ±.08
Percentage of Change	18.75%		-2.76%	
t-value☼	5.29		-1.97	
P-value	0.0005		0.064	

MLSI=Medio-Lateral Stability Index SE= Standard Error.
☼= Level of significance at P<0.05 * = significant



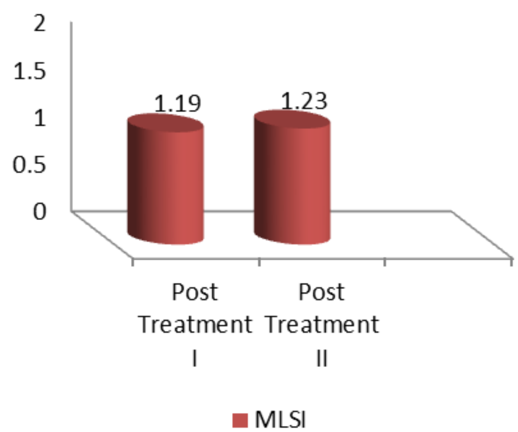


Fig.6Medio-Lateral Stability Index in group (A), study Medio-Lateral Stability Index in group (B), control

Comparison between the two groups A&B regarding balance parameters APSI&MLSI after Eight weeks of training:

The results of this study revealed that there were no statistical significant differences between the two groups after eight weeks of training in the measured variables including the two parameters of balance index [Antero-posterior stability index (ASI) and medio-lateral stability index (MSI)], where t-value was [(1.66) & (0.847)] and p-value was [(0.205) & (0.363)] for APSI and MLSI respectively. This means that both Circuit weight training and treadmill training have beneficial effects on balance parameters, as shown in (Table 7). Results are illustrated in Fig.7.

Table (7) Comparison between the two groups (A&B) regarding balance parameters (APSI &MLSI) after Eight weeks of training.

Group / Variables	Post-treatment I			
	APSI		MLSI	
	Group(A)	Group(B)	Group(A)	Group(B)
Mean ±SE	- 29.08±2.82	- 53.81±4.41	- 33.69±3.81	- 56.12±4.42
t-value☼	1.66		.85	
P-value	0.205 **		0.363 **	

APSI=Antero-posterior Stability Index MLSI=Medio-lateral Stability Index SE = Standard Error. ☼= Level of significance at P<0.05 **= non-significant

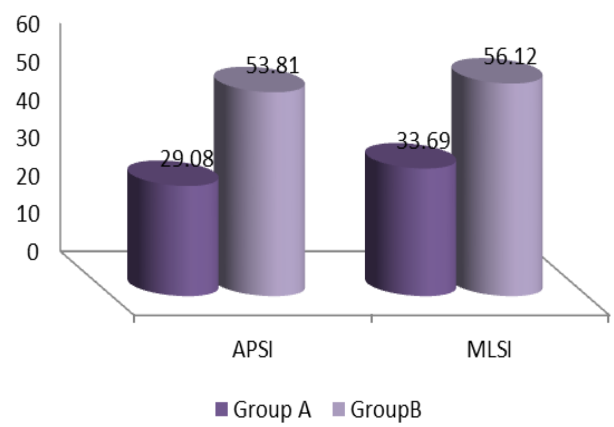


Fig.7 Comparison between the two groups (A&B) regarding balance parameters (APSI &MLSI) after Eight weeks of training.

Comparison between the two groups A&B regarding balance parameters APSI&MLSI after four weeks of training cessation:

The results of this study revealed that there were statistical significant differences between the two groups after four weeks of training cessation in the measured variables including the two parameters of balance index [Antero-posterior stability index (ASI) and medio-lateral stability index (MSI)], where t-value was [(29.389) & (11.738)] and p-value was [(0.0001) & (0.001)] for APSI and MLSI respectively, this means that circuit weight training is more effective and alternative to treadmill training in improving balance index in type 2 diabetic polyneuropathy for more extended period of time., as shown in (Table 8). Results are illustrated in Fig.8.

Table (8) Comparison between the two groups (A&B) regarding balance parameters (APSI &MLSI) after four weeks of training cessation.

Group / Variables	Post-treatment II			
	APSI		MLSI	
	Group(A)	Group(B)	Group(A)	Group(B)
Mean ±SE	14.42±2 .89	1.15±0 .77	18.62±3 .69	4.62±2 .01
st-value☼	29.39		11.74	
P-value	0.0001*		0.001*	

APSI=Antero-posterior Stability Index MLSI=Medio-lateral Stability Index SE = Standard Error. ☼= Level of significance at P<0.05 * = significant

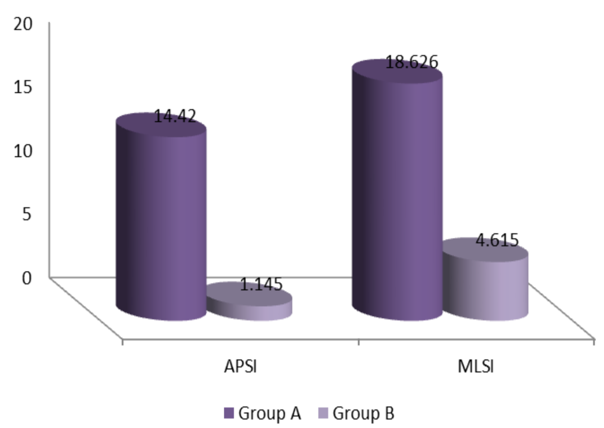


Fig. 8 Comparison between the two groups (A&B) regarding balance parameters (APSI &MLSI) after four weeks of training cessation.

DISCUSION

Polyneuropathy, a common complication of diabetes mellitus, is generally considered to be related to duration and severity of hyperglycemia. However, it may also occur acutely even with hypoglycemia [2].

Diabetic polyneuropathy is a chronic and devastating complication of diabetes mellitus (DM), characterized by the progressive loss of somatic and autonomic nerve fibers. Diabetic neuropathy (DN) is the most common peripheral neuropathy in the Western world and leads to significant morbidity and impact on quality of life of patients. As the nervous system is the most dependent tissue on glucose and oxygen, DM can potentially affect any part of the nervous system [36].

Most studies use traditional aerobic exercise or resistance training (i.e. strength) interventions, however, more novel interventions such as circuit training could provide a more effective and appropriate exercise modality. Circuit training usually consists of discontinuous exercise involving exercising for a fixed number of repetitions using a series of stations involving light resistance training (RT). Each station usually involves an equal exercise: rest ratio lasting .The active recovery (aerobic exercises) between resistance stations was designed to maintain exercise HR within the training zone to facilitate changes in cardio respiratory fitness and maximize energy expenditure [21].

Exercise may positively influence the pathological factors associated with neuropathy by promoting microvascular dilation, reducing oxidative stress, and increasing neurotrophic factors [23; 14; 17]. Because of various exercise therapy protocols that can be utilized by T2DM patients. There was persistence need to examine which one is the best or on other word how to decide which one will provide the best, long lasting effect for those increasing diabetic population worldwide. So, the purpose of this study was to investigate the effect of circuit weight training (CWT) program on sway indices (antero-posterior stability index, medio-lateral stability index) in diabetic patients with neuropathy on the short-run (after 2 months training) and long-run (additional 1 month follow up without training).

Efficacy of circuit weight training; using free weights and weight machines were studied on the following variables: (antero-posterior stability index, medio-lateral stability index). These variables were assessed initially before starting the training program (pre-training) and after the end of the training program (post-training-1) and after another one month in both groups (post-training-2). The results of this study revealed that the circuit weight training program seems to produce more favorable and longer lasting improvement (on long run basis) on balance variables in type 2 diabetic patients of the same population.

Results of this study showed clearly that training by CWT; had more significant positive effects on balance index values in diabetic neuropathic patients on long run basis. These results were compared with those of diabetic neuropathic patients (control group) who showed significant changes in balance index values.

The result of this study came in accordance with Akbari who found that diabetic patients who experience peripheral neuropathy and consequent balance problems can achieve better balance and stability through progressive balance training with emphasis on the anterior-posterior neuromuscular elements of stability1.

In agreement with the results of the current study, Hijmans showed that balance training can improve the balance ability of neuropathic diabetic patients and emphasized the positive effects of balance training exercises on stability and body stability[15].

The result of this study came in accordance with Salsabili who found that training using sensory and reactive movement strategies with external visual feedback improves standing postural control in patients by modifying the subclinical constraints that DN contribute to disordered balance [30].

These results were consistent with the findings of Nagy who studied elderly subjects who participated in combined biweekly training for 8 weeks. Their exercise program included combinations of lower-limb strength and flexibility exercises, static and dynamic balance exercises, and walking as an aerobic activity. Their balance confidence and control of ML balance in response to the 8 weeks training improved, and the higher ML direction frequency power exhibited after the training may indicate better balance performance [26].

The result of this study came in accordance with Nardone who confirmed that balance rehabilitation with either specific physical exercises or a powered platform is effective in patients with balance disorders of neuropathic origin; thus, it contributes to increasing stability and potentially decreasing the risk of falling in patients with neuropathy [27].

In agreement with the results of the current study Mattacola and Lloyd confirmed that balance training is a useful method to improve balance in frail and nondisabled elderly people and confirmed our results, which show the effectiveness of balance training in patients with DN [24].

Moderately intense levels of aerobic and resistance training have been found to be effective at improving glycemic control in older adults and in people with diabetes. There are significant improvements in measures of pain, neuropathic symptoms, and cutaneous fiber branching in people with diabetic peripheral neuropathy [22].

The health benefits of exercise training, including improvements in insulin sensitivity and glycemic control, are commonly attributed to the adaptations associated with chronic exercise, including increases in cardiorespiratory fitness, changes in energy balance, or reductions in total or regional adiposity [4].

Seven days of exercise training typically improves insulin sensitivity measured via the hyperinsulinaemic–euglycaemic clamp in patients with type 2 diabetes. Daily exercise improves day-to-day glycemic control, reducing the frequency, magnitude and duration of glycemic excursions in previously sedentary patients with type 2 diabetes under free-living conditions [25].

Circuit weight training improves insulin sensitivity independent of changes in body composition. Restoring insulin sensitivity by aerobic exercise and CWT might be mediated mainly by mechanisms other than adiponectin, for instance, by the Adenosine monophosphate (AMP)-activated protein kinase pathway 39. Biochemically, it is hypothesized that exercise-induced increases in AMP activated protein kinase (AMPK), an enzyme that, among many other functions, stimulates glucose uptake and FA oxidation while decreasing lipid synthesis, may explain the observed associations between exercise and reduced metabolic disease although present in all human cells, AMPK is notably activated by exercise in skeletal muscle fibers [29].

Exercise was found to have many benefits on health status, such as cardiovascular fitness, optimum body weight and muscle mass maintenance, decreasing abdominal fat and improving insulin sensitivity [31].

Furthermore; moderate intensity exercise has a longer lasting effect on lipoprotein lipase in muscles and hepatic lipase in liver, and also it increases lipid uptake and oxidation in skeletal muscles, so leads to improvement in insulin action and decrease glucose and TG level and this can explain the sustained improvement in balance index despite cessation of training 3.

CONCLUSION

Our findings support the undeniable benefits of physical activity in T2DM patients. In conclusion, this study added to the limited literature concerning the follow up benefits of the circuit weight training effects in T2D patients with polyneuropathy.

The role of circuit resistance on the short or long term effects on balance index was noteworthy. The significant improvement in balance index in response to the circuit resistance training and treadmill training groups indicate the importance of physical activity on balance abnormalities in these patients on short term effect but only for CWT on long term effect.

It also seems that the long term improvement in balance index in the circuit resistance training were more significant than control group. The results of this study supported the importance of circuit weight training to improve balance in type 2 diabetic neuropathic patients and showed that diabetic patients who follow this exercise program should be able to safely improve their balance response and decrease neuropathic symptoms and hence decrease the incidence of diabetic complications. Also, safely improve muscular strength and reduce stress which can not only improve many metabolic; but also substantially improve capacity for independent living and enhanced quality of life, here; the circuit weight training is the matter of concern.

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