Efficacy of Tai Chi Exercise on Balance in Lower Limb Ulcers

Eman Mohamed Othman Mohamed, Adel Abd- El- Hamid Nossier and Mohamed Al-Shrief Al-Sarky

ABSTRACT

Purpose: *This study was designed to investigate the effect of Tai Chi exercise on improving dynamic balance in lower limb ulcers cases.* ***Subjects:*** *Forty patients (11 female and 29 male) were included in this study. Their ages ranged from 40 to 60 years. They were randomly divided into two equal groups.* ***Procedures:*** *Group (A) received 6 weeks of Tai Chi exercise (IB program) for 15 to 40 min 3 times per week in addition to medical treatment while group (B) received their standard medical treatment only. The Biodex balance system was used to measured dynamic balance just before treatment and after 6 weeks of treatments. Measurement were taken for all patients with opened eyes and closed eyes.* ***Results:*** *This study showed significant difference in balance performance between experimental and control groups. Overall stability index was significantly decreased ($P \leq 0.05$) and the balance performance was significantly improved ($P \leq 0.05$) in the exercise group with eyes opened (2.59±0.49 with 35.41% improvement) and highly significant improved in the exercise group with eyes closed (3.99±0.73 with 46.44% improvement).* ***Conclusion:*** *The suggested exercise produced improvement in balance disturbance and considered as a gold tool in the management of dynamic balance in foot ulcers as the rate of falling can decreased in those patients.*

Key words: *(Lower limb ulcer, Dynamic balance, Tai Chi exercise & Biodex stability system).*

INTRODUCTION

Chronic lower limb ulcers are a significant burden to both patients and the health care system[13,27]. Foot and leg ulcers are serious complications because they often precede lower-limb amputations[32,39]. International studies demonstrate that lower limb ulcer occurrence increases with age[18].

The causal pathways leading to foot ulceration include several component causes, the most important of which is peripheral neuropathy[36]. Diabetic peripheral neuropathy is the main cause of sensory and motor deficit of the feet: as a result, motor control of gait compromised, nerve degeneration may cause muscle weakness and atrophy, and plantar ulcers may occur[10].

The loss of sensation associated with diabetic peripheral neuropathy (DPN) thought to contribute to impaired balance, altered gait patterns, and increased risk of falling[11].

Postural control is the maintenance of upright posture, typically involves the use of most of the body's major muscle groups; the visual, haptic, and vestibular systems and sometimes the auditory system. Postural control is essentially a matter of achieving postural stability[41]. Postural sway typically consists of small amplitude motion, it can be a threat to balance and thus becomes a challenge for the control of posture. Studying dynamic postural control adds additional demands of proprioception, range of motion, and strength while attempting to maintain an upright and steady posture[20].

The Biodex Balance System (BBS) has been used to evaluate postural balance in recent years. There is high reliability for BBS to evaluate dynamic postural balance[28].

Exercise that improves lower extremity balance and strength (force-generating capacity) has been shown to be effective in reducing falls in older adults[6,15,17,35]. However, people who are sedentary and people with insensate feet have an increased risk of falling[45]. There is evidence suggesting that daily weight-bearing activity may decrease the risk of foot ulceration[2,29].

Previous studies has designed to assess the effect of Tai Chi training on balance has found that after training there is a lengthening of time to the first fall, maintenance of balance improvements acquired by other balance training, and improvement on standing measures of balance[47,52]. Therefore this study was carried out to determine the effect of Tai Chi exercise program on balance in lower limb ulcers.

SUBJECTS, MATERIALS AND METHODS

Subjects

Forty volunteers (11 female and 29 male) who had chronic unhealed unilateral lower limb ulcers grade II and grade III (located on the sole of the foot) associated with postural sway symptoms. The subjects were chosen under the following criteria: The age of the patients ranged from 40 to 60 years. Their weight ranged from (60kg -90kg) and height from (150cm - 170cm). All were patients examined by physician before the study. All patients received the same medical care and free from any pathological conditions that might affect the results. All patients should be conscious and ambulant.

Procedures

Measurement procedures

The Biodex balance test was performed to test the patient's ability to control the platform angle of tilt. The measurement procedures were taken as follow:

Each patient was asked to stand on the center of the locked platform with two legs stance bare feet with affected leg dressed and the other undressed. All patients were tested on stability level (8) (most stable platform) initially and at the end, all patients were tested for 30 seconds. The patient was instructed to try to achieve a centered position on the platform, (once the platform set to motion). This was accomplished by shifting the position of his feet to a position which is easy to keep the cursor on the visual feedback screen in the center of the screen grid. The measurement were taken with opened eyes and closed eyes. At the end of each test trial a print out report obtained. This report included information as regard: Over all stability Index: Represented the patient's ability to control their balance in all directions. High values represent patient had difficulty[8].

Therapeutic procedures

- Exercise therapy protocol (exercise therapy procedure):

In Balance (IB) program, derived from principles of Tai Chi, the IB program included the 7 therapeutic elements of Tai Chi that have been identified as most beneficial for elderly persons[48]. In the beginning of the program, attention was paid to somatosensory feedback signals coming from ankle and hip motions that can be used as input for balance control. Combined with exercises increasing ankle range of motion, proprioception and sensation can be improved[43], and co-contractions that are often present to compensate for diminished sensory input may be removed[51]. Later in the program, Tai Chi forms were introduced with the emphasis on slow and continuous motions, trunk rotation, and weight shifting. The exercises were tailored to the individual abilities of the participants, in that participants were allowed to perform some exercises in a sitting instead of standing position because of fatigue or poor balance control[33].

- Exercise therapy procedure (IB program):

The exercise interventions were performed day after day on a firm surface for 6 weeks included:- Relaxation exercises, Stretch and relax exercises, Pelvis exercises, Foot and ankle exercises, Leg strengthening, Balance exercises, and Functional exercises[33].

For all exercises: Repeat as often as needed and if needed the exercises can be performed seated in an armless chair. Movements are made slowly and as big as possible.

RESULTS

a- Results of stability indices for experimental group:

- As reflected from table (1), there were statistical significant reduction ($P<0.05$) in stability index with opened eyes and with closed eyes, after 6 weeks of treatment (post-treatment) in the exercise group with ($P= 0.01$). The percentage of improvement in stability index (SI) with opened eyes was 35.41% and with closed eyes of 46.44%after 6 weeks of treatment (post-treatment).

Table (1): Comparison between pre and post-treatment applications values of stability index (SI) with eyes opened and with closed eyes in the experimental group (group A).

	Stability Index (SI) with Opened Eyes		Stability Index (SI) with Closed Eyes	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
X	4.01	2.59	7.45	3.99
±SD	±1.09	±0.49	±1.22	±0.73
Maximum	5.6	3.4	9.3	5.3
Minimum	1.9	1.7	5.3	2.8
MD	-1.43		-3.46	
% of improvement	35.41%		46.44%	
t-value	-8.46		-16.66	
P-value	0.01		0.01	
Level of significance	S↓		S↓	

X = Mean, ± SD= Standard deviation, MD =Mean difference, P-Value=Probability level, %=Percentage, Pre = before application of treatment, Post = after 6 weeks of treatment.

b- Results of stability indices for control group:

There were statistical significant reduction (P<0.05) in stability index with opened eyes and with closed eyes, after 6 weeks of treatment (post-treatment) in the control group with (P= 0.01). The percentage of improvement in stability index (SI) was 9.17% with opened eyes and with closed eyes of 2.797% after 6 weeks of treatment (post-treatment).

c- Comparison between both groups of the study:

As revealed form table (2), fig (1) and fig (2) that the stability index with opened eyes had a significant decrease after treatment, also the stability index with closed eyes had a highly significant decrease after treatment for exercise group when compared with the control group.

Table (2): Comparative analysis of stability index (SI) between two groups of the study with opened eyes and with closed eyes.

	Stability Index (SI) with Opened Eyes				Stability Index (SI) with Closed Eyes			
	Pre-treatment		Post-treatment		Pre-treatment		Post-treatment	
	Exercise group	Control group	Exercise group	Control group	Exercise group	Control group	Exercise group	Control group
X	4.01	4.36	2.59	3.96	7.45	7.15	3.99	6.95
±SD	±1.09	±1.03	±0.49	±0.92	±1.22	±1.21	±0.73	±1.15
MD	0.35		1.37		-0.3		2.96	
T-Value	1.05		5.87		-0.78		9.72	
P-Value	0.30		0.01		0. 98		0.04	
Level of significance	N.S		S↓		N.S		S↓	

X = Mean, ± SD= Standard deviation, MD =Mean difference, P-Value=Probability level, %=Percentage, Pre = before application of treatment, Post = after 6 weeks of treatment

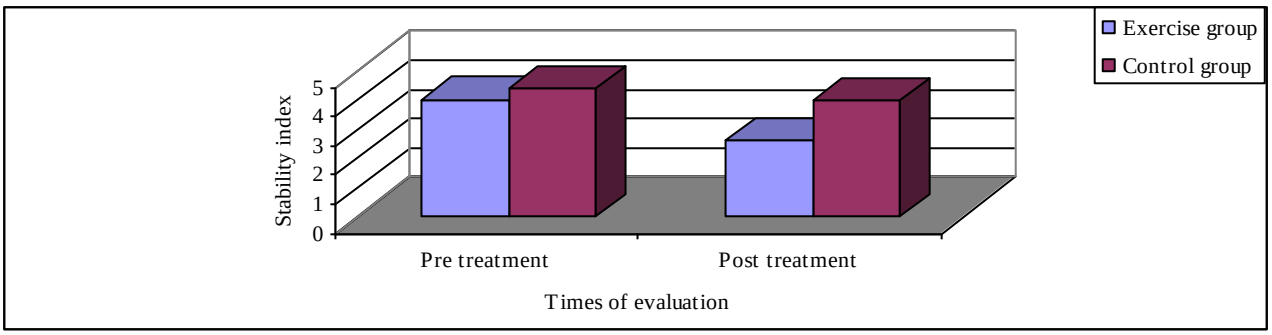

Fig. (1): Shows a comparison of stability index (SI) with opened eyes (pre- and post -treatment) between both groups of the study.

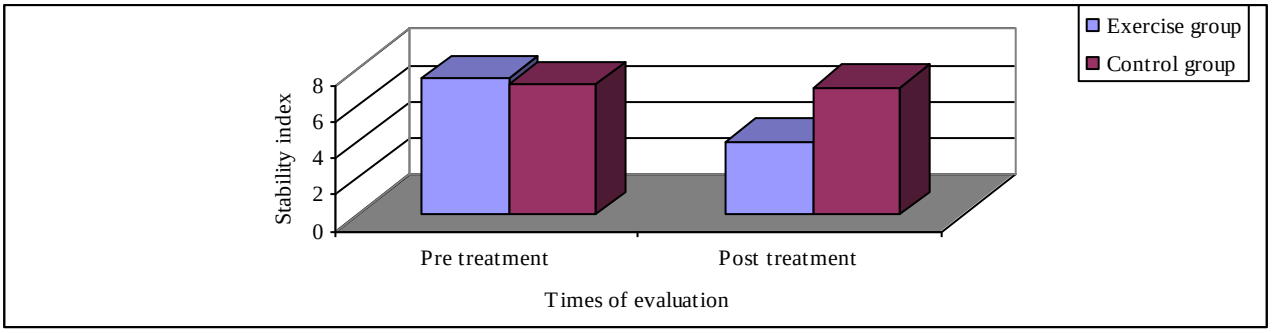

Fig. (2): Shows a comparison of stability index (SI) with closed eyes (pre- and post -treatment) between both groups of the study.

DISCUSSION

- The parameter investigated in this study involved the overall stability index (dynamic postural control assessment) with both eyes opened and with eyes closed for both groups.
- Dynamic balance was measured by using the Biodex balance system is extremely effective, providing instantaneous feedback that makes it easy for patients to relate to and reproduce specified motion patterns.

A. Important factors that affect normal postural stability:

The postural control system utilizes complex processes involving both sensory and motor components. Maintenance of postural equilibrium requires sensory detection of body motions, integration of sensorimotor information within the central nervous system (CNS) and execution of appropriate musculoskeletal response[1].

Several factors found to have variable effects on the postural stability such as mechanorecptors in the sole of foot, proprioception, fatigue, amputation, decreased balance confidence, and the effect of diseases[22,28].

B. Foot ulceration impairs the ability to control postural stability, therefore lower limb ulcers can cause postural instability:

From several studies and researches, the lower limb ulcers can cause one or more of the following factors that affect the balance: loss of mechanoreceptors in the sole of the foot, loss of proprioception in the lower limb, decreased balance confidence, and fatigue of lower limb muscles. Furthermore, lower limb ulcers can result from peripheral neuropathy especially diabetic peripheral neuropathy, which considered as one of the main causes of balance disorders, therefore the patients with lower limb ulcers have defect on balance[2,19,25,29].

C. Reliability of balance test by Biodex balance system (BBS):

On the current study, the post-treatment of balance assessment was identical to the pre-treatment and was performed at the beginning of the study and at the end of the study with the eye opened and eye closed for both groups. All factors that may affect the balance and the result had been controlled as much as possible including age, weight, height, types of ulcer, diabetes, medical treatment, and special habits. Measurement of balance by Biodex balance system (BBS) has been employed by Aydog et al. (2005)[4], Capuno et al. (1995)[8], Hinman, (2000)[23] & Karimi et al. (2008)[28] who reported that BBS have been considered reliable.

In the present study, the variable used to measure the performance of patients was the overall stability index as it considered the most reliable variable. This is supported by Hinman, (2000)[23].

In the present study, a combination of relaxation exercises, stretching exercises, pelvic exercises, foot& ankle exercises, leg strengthening, balance exercises, and functional exercises were found to augment balance control in the lower limb ulcer cases. This is supported by Hauer et al., (2001)[21] and Nitz and Low, (2004)[37].

In the present work, the IB program derived from principles of Tai Chi was used for controlling balance as (Marjan et al., 2006[33]; Skelton, 2001[43]; Wolf et al., 1997[48] &

Woollacott, 2000[51]) suggested that it is the optimal treatment schedule appropriate for elderly persons.

The findings of this study indicate a considerable difference between results of exercise therapy group and control group in the dynamic balance irrespective to overall stability index with both eyes opened and eyes closed. This finding revealed that the exercise therapy program was significantly more effective in controlling postural stability. This results was consistent with those reported by Campbell et al. (1997)[7] Gillespie et al., (2009)[17] & Wolf et al., (2001)[46].

On the other hand a number of randomized placebo controlled studies have not been able to demonstrate any significant or convincing clinically relevant effect of exercises on balance Lord et al., (2005)[31]; Nitz and Low, (2004)[37] & Sakamoto et al. (2006)[40].

***Stability index for patients with opened eyes for both groups:**

The results of the present study demonstrated that the stability index with opened eyes had a significant decrease (improvement) after Tai Chi exercise application for study group when compared with control group, which indicated significant effect of Tai Chi exercise. This finding was consistent with those reported by Fong and Ng, (2006)[12]; Orr et al. (2006)[38]; Wolf et al. (1996)[47] & Woollacott, (2000)[51].

On the other hand some trials failed to show any significant difference of Tai Chi exercises on balance Wolf et al. (2003)[49] & Woo et al. (2007)[50].

The mean value of stability index (SI) in patients of the exercise group (group A) with opened eyes after 6 weeks of treatment application (post-treatment) was 2.59±0.49, while in the control group (group B) was 3.96±0.92. The percentage of improvement (decrease) from the control group in the stability index with the exercise group was 35.41%. This improved value of stability index with opened eyes was consistent with that observed by Tse and Bailey, (1992)[44].

On the other hand some studies reported by Choi et al. (2005)[9] & Woo et al. (2007)[50] failed to show any significant difference of Tai Chi exercises on balance with eyes opened.

The difference between stability index (with opened eyes) of exercise group and that of control group may be due to the following causes:

1- Increase the proprioceptive coordination of movement.
2- Increase kinesthetic sensation and the stimulation of vestibular system.
3- Increase the force production and muscle shear force.
4- Improved the local dynamic stability and the body awareness.

This explanation was proved and reported by Gallagher, (2003)[14] & Li et al. (2001)[30].

***Stability index for patients with closed eyes for both groups:**

The results of the present study demonstrated that the stability index with closed eyes had a significant decrease (improvement) after Tai Chi exercise application for group (A) when compared with group (B). This finding was consistent with those reported by Gauchard et al. (2003)[16] & Hong et al. (2000)[24].

The mean value of stability index (SI) in patients of the exercise group (group A) with closed eyes after treatment was 3.99±0.73, while in the control group (group B) was 6.95±1.15. The percentage of improvement (decrease) from the control group in the stability index with the exercise group was 46.44%. This improved value of stability index with closed eyes was consistent with that observed by Gauchard et al. (2003)[16] & Hong et al. (2000)[24].

On the other hand some studies reported by Audette et al. (2006)[3] & Wolf et al. (2003)[49] failed to show any significant difference of Tai Chi exercises on balance with eyes closed.

The difference between stability index (with closed eyes) of exercise group and that of control group may be due to the following causes:

1- Enhancement of the vestibular adaptation.
2- Contribute to the quality of care for those with learning difficulties.
3- Increase the focus on postural awareness and equilibrium maintenance.
4- Increase joint stability and lubrication.

This explanation was proved and reported by Horak et al. (1992)[26], Wolf et al. (1997)[48] & Yu, (2002)[53].

***Comparison between stability index with both eyes opened and eyes closed in the exercise group (group A):**

The results of the present study demonstrated that the stability index with closed eyes had a higher significant improvement than that with opened eyes indicated greater success in the rate of balance control when the eyes closed. Even more than the rate of balance control when the eyes opened. The difference between stability index of both with opened and closed eyes of exercise group may be due to the following causes:

1- With absent vision the focus is on the mind and consciousness more than with opened eyes, which give more confirmation on the principle of Tai Chi exercise.
2- Improve vestibule-ocular adaptation and interaction.
3- Increase the self-confidence and the balance confidence.
4- Coordination of sensory motor function.

This explanation was proved and reported by Boucher et al, (1995)[5].

From the previous discussion of these results, and according to the reports and researches of other investigators in the field related to the present study, we can claimed that lower limb ulcers leads to decrease postural stability. Also using IB program of Tai Chi exercise, which is easily applied for old age patients with lower limb ulcers, induced a greater improvement of overall stability index, and a better control of balance in lower limb ulcer cases.

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الملخص العربي

فاعلية تمرين تاى تشى علي التوازن في قرحات الطرف السفلي

يعتبر اختلال الاتزان أحد أبرز مشاكل قرحات الطرف السفلي وذلك لأنها تؤدي إلى ارتفاع معدل السقوط وبالتالي الإعاقة . لذلك كان هدف الدراسة هو معرفة تأثير برنامج التمارين العلاجية على الاتزان في قرحات الطرف السفلي . شارك في هذه الدراسة أربعون مريضا من الذكور والإناث تراوحت أعمارهم بين 40-60 سنة ، وتم تقسيمهم عشوائيا إلى مجموعتين متساويتين: (مجموعة الدراسة) : تحتوي هذه المجموعة على عشرين مريضا ممن عانوا من قرحة الطرف السفلي ، وشمل البرنامج العلاجي للمجموعة على تمرين تاى تشي للتوازن من أوضاع مختلفة وذلك إلى جانب العلاج الطبي التقليدي . ومدة العلاج تتراوح ما بين 15-40 دقيقة ثلاث مرات في الأسبوع لمدة 6 أسابيع . (المجموعة الضابطة) : تحتوي هذه المجموعة على عشرين مريضا ممن تلقوا العلاج الطبي التقليدي فقط . تم قياس التوازن الديناميكى باستخدام جهاز قياس الاتزان الالكتروني ، وأجري هذا القياس قبل الدراسة وبعد مرور ستة أسابيع من الدراسة والقياس تم وأعين المريض مفتوحة مرة وأعين المريض مغلقة مرة أخري . ظهرت النتائج أن هناك فروق ذات دلالة إحصائية بين المجموعتين مع الأعين مفتوحة وأيضا والأعين مغلقة مع نسبة أكبر من التحسن والأعين مغلقة وأيضا نسبة أكبر من التحسن في مرضى المجموعة الأولى . ويستخلص من نتائج هذا البحث ضرورة مزاولة مرضي قرحة الطرف السفلي تمرين تاى تشى للتوازن بصفة مستمرة وذلك لما لها من تأثيرات ايجابية علي الاتزان الديناميكي لدى هؤلاء المرضي .