Efficacy of Selected Balance Training Program on Postural Instability in Parkinson's Patients

Hoda M. Zakaria, Ph.D., P.T* and Sahar M. Adel, Ph.D., P.T**
* The Department of Physical Therapy for Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University.
** The Department of Physical Therapy for Basic Science, Faculty of Physical Therapy, Cairo University.

ABSTRACT

The aim of this study *was to evaluate the degree of impairment of postural stability in parkinsonian patient and to investigate the influence of selected balance training program on Biodex stability system on postural instability of parkinsonian patient.* ***Subjects and Method:*** *Thirty patients with idiopathic Parkinson's (PD) aged from 50 to 65 years participated in this study. They were assigned into two equal groups, the study group (group I), mean age = 56.27±5.97, with duration of illness = 5.13±1.73 received specific selected balance training on Biodex stability system, in addition to traditional physical therapy program while the control group (group II), mean age = 57.87±6.74, with duration of illness = 4.47±1.46 received traditional physical therapy program. Each treatment program was conducted three times per week, for eight weeks. Assessment was done before and after treatment sessions by measuring Stability index, Dynamic limits of stability, Berg balance scale and Unified Parkinson's Disease Rating Scale (UPDRS).* ***Results:*** *The results of this study showed a significant reduction in postural instability parameters in PD patients in comparison to normal predicted value. Moreover, the results of this study revealed statistically significant improvement in postural stability in the study group more than the control group.* ***Conclusion:*** *It can be concluded that the selected balance training program on Biodex Stability System is a beneficial modality that can be used to improve the postural instability in parkinsonian patient.*
Keywords: *Parkinson's Disease, balance, postural instability.*

INTRODUCTION

Parkinson's disease (PD) is a slowly progressive neurologic disorder by degeneration of dopaminergic neurons in the substantia nigra. Tremors, bradykinesia, rigidity, postural instability, flexed posture and gait disturbance are cardinal features of Parkinson's disease[11].

Postural instability (PI) or impaired balance, is common in idiopathic Parkinson's disease (IPD), in many cases leading to falls, which are one of the main causes of hospitalization in such patients. Moreover, balance impairment often induces psychological reactions characterized by fear of future falling. This fear of falling may be protective if it interferes only with hazardous activity and increases caution during performance in all other daily living tasks, but it can be maladaptive when it compels patients to restrict their mobility, independence and social participation, leading to further deconditioning, functional decline, and poorer quality of life[15].

Postural instability is one of the most incapacitating factors in PD, which, together with gait impairment, leads invariably to

repeated falls, increased morbidity, reduced quality of life, progressive handicap, and eventually an increased mortality risk[20]. It is a severe problem in these patients and becomes more and more with progression of the disease. This is due to several impaired functions related to postural control as inappropriate response to external stimuli, insufficient postural muscle tone and deficits in postural synergies[13].

Causes of Postural instability in PD involve many related factors, including alterations of balance control mechanisms, rigidity and static posture abnormalities, gait impairment, autonomic dysfunction particularly orthostatic hypotension, impairment of visuo-spatial tasks and anxiety-related fear of falling[1].

Preventing falls is very important for older people and for society. Furthermore, falls are the most common cause of injuries and hospital admissions among people aged 65 years and older, accounting for 87% of all fractures, and are the second leading cause of spinal cord and brain injuries. Falls also lead to psychological trauma, motor deficits, and loss of autonomy, as well as enormous economic costs[2].

Rehabilitation continues to evolve with the increased emphasis on patient management and proprioceptive training. The Biodex stability system is a recent device to assess and train the balance ability. The system is a commercially available postural stability assessment and training system, designed to stimulate joint mechanoreceptors and to promote reflex muscular activation necessary for joint stability[18].

So, the purpose of this study was to investigate the efficacy of balance training program on Biodex stability system on postural instability of parkinsonian patients.

MATERIALS AND METHODS

Thirty patients diagnosed as PD were selected from the Out-patients Clinics of Neurology of Kasr El-Aini Hospitals and Faculty of Physical Therapy, Cairo University.

Those patients followed the following criteria:

- Their age ranged from 50- 65 years.
- All patients suffered from balance disturbance (total Berg Balance scores less than 45 points).
- They were medically stable.
- All patients were selected according to modified Hoehn and Yahr classification of disabilities (stage II, III).
- All patients were co-operative and able to follow all the instructions.
- None of them suffering from hearing, visual or cognitive impairments, or associated deformities.

The patients were randomly assigned into two equal groups:

Group (I) The study group consisted of 15 patients received selected balance training program on Biodex stability in addition to traditional physical therapy program.

Group (II) The control group consisted of 15 patients received traditional program in form of : (Rhythmic initiation, counter pressure of shoulder against pelvis, postural exercises, conductive education and balance training). Physiotherapy program of balance training consisted of graduated standing balance exercises, through shifting the head forward, backward, right and left rotation. This was followed by raising both arms gradually upwards till the maximum. Then, moving trunk forwards, backwards and sideway to the right and to the left. This was followed by pushing the patient in different directions from stride standing then from walk standing position. Then, standing on one foot alternatively. The duration of the traditional

program in both groups was conducted in 45 minutes per session.

Instruments:

1- Instruments for evaluation:

The Biodex stability System (Biodex corporation, Shirley, NY, USA) was used to assess overall stability index (OASI) and dynamic limit of stability (DLOS) of the patient before and after treatment. The stability is believed to be the best indicator of the overall ability of the patients to balance performance, in which the larger stability index the greater the degree of instability[21]. It consists of a movable balance platform which provides up to 20º of surface tilt in a 360º range and is interfaced with a microprocessor-based actuator. The actuator controls the manually preset degree of surface instability, which ranges from a completely firm surface (stability level 8), to a very unstable surface (stability level 1). The degree to which the platform tilts is dictated by the subject's balance ability. During postural stability testing, the patient's ability to control the platform's angle of tilt is quantified as a variance from center. A large variance is indicative of poor neuromuscular control. During dynamic limits of stability (DLOS) testing, the patient's ability to move from one target to another in a straight line is quantified from a total score of 100 (100 being perfect). For postural stability testing, the degree of surface instability is controlled by microprocessor actuator. The Biodex Balance System allows accurate test and quickly generate a printed report[8].

2- Instrument for treatment:

The Biodex balance system was used for training of static and dynamic balance of the study group. This system focuses on the proprioceptive neuromuscular mechanisms that appear to affect both static and dynamic balance. The system acts as a valuable training device to enhance kinesthetic abilities that may provide some degree of compensation for impaired proprioceptive reflex mechanisms following injury[19].

Procedures:

Assessment Procedures:

Postural stability for all patient was assessed through : 1) The Biodex stability system, 2) Berg balance scale (BBS), 3) Unified Parkinson's Disease Rating Scale (UPDRS). Purpose and procedure of the study were explained for all patients before assessment and treatment program.

1) The Biodex stability system

Patient preparation:

- The detailed sheet was done to every patient. The patient's weight and height were measured and recorded in the evaluation sheet with other information.
- Patients in the study group were given a brief explanation about the training procedures by using the Biodex Balance System. All patients were asked to avoid anxiety, exercises and eating at least two hours before the conduction of the evaluation and treatment protocols and wear comfortable and suitable clothes during the procedures.
- To ensure patient safety, each session was begun with the platform in the locked position. The support rail and biofeedback display were adjusted to ensure patient's comfort and safety.

Instrument preparation: The instrument was adjusted as follows:

- The cable was connected and the instrument was turned on, the Biodex logo screen appeared, all computer functions of

the balance system were controlled from the display panel keys.

- The position of the support handles and its height were adjusted according to the patient's height and comfort.
- The display height and tilt were adjusted for the patient's comfort.
- The weight, height and age of the patient were entered to the control screen display located in front of the patient's eyes.
- The platform firmness was adjusted at level 8 (the most stable level).
- The foot position and angle for each patient were recorded on the control display.
- The stance type was adjusted at two leg stance.

Assessment of Overall Stability Index

Patients were encountered to the apparatus and adjust the support handles and visual screen display. Patient was instructed to stand up on the foot platform, grasp the support handles at the beginning of the test. For successive trails at level eight. The patient was asked to try to maintain center position on platform through keeping the cursor on the visual feed back screen. The test trial ended and the platform automatically returned to the locked position. At this point, the balance index reading was displayed reflecting the patient's overall performance in terms of platform deviation from the level position. The data was printed. Additional test trials (second and third) were performed and the mean was calculated.

The data generated from this test was in the form of balance index which include:

- Overall stability index (OASI)- Anterior / posterior (A/P) index - Medial/ lateral (M/L) index.

Assessment of Dynamic Limits of Stability:

The system was adjusted as before in addition the test difficulty was sit at the easiest level (50% LOS), then the patient was instructed to begin the test and the platform advanced to an unstable surface. The first test trial was then begun. The countdown clock at the lower right of the screen provided a three seconds countdown time. When the countdown completed, the LOS test screen displayed eight boxes arranged around a central box. The boxes on the top portion of the screen represented the anterior medial and lateral limits of stability. The boxes to the left and right of center represented medial- lateral limits of stability. The boxes at the bottom of the screen represent the posterior limits of stability. Once the test begun, the patient tried to move the cursor to the box which appeared on the screen and then back to the center box with as little deviation as possible. The boxes appeared in random order until the patient complete all eight boxes.

Elapsed time was displayed at the bottom of the left side of the screen. Once the patient completed all eight boxes, the clock stopped and the test trial ended, the platform automatically returned to the locked position. The data was printed and additional test trials (second and third) were performed and the mean was calculated.

The data generated were recorded in the form of directional control and time elapsed to complete the test. If all of the patient's movements were directly toward the target straight line), then the amount of extraneous movement would equal zero, and the perfect directional control score was 100%. In other words, high (close to 100%) directional scores are good, lower scores are worse.

2) Berg balance scale (BBS):

The scale consists of 14 items that individuals perform in their daily routines. The base of support was decreased gradually, thus making tasks more difficult. The BBS is scored on a scale of zero to four. Zero being an inability to perform the task and four being the ability to perform the task safely and independently. The maximum score is 56 points. Patients who had scores less than 45 points will participate in this study[3]. The maximum score is 56 points.

3) Unified Parkinson's Disease Rating Scale (UPDRS):

Subscale for postural stability was measured before starting the treatment and after the last treatment sessions. This was done by assessing the patient's response to sudden posterior displacement produced by pull on shoulders while being erect with eyes open and feet slightly a part)[6].

Grades of the scale

0 = normal.

1 = retropulsion, but recovers unaided.

2 = absence of postural response, would fall if not caught by the examiner.

3 = very unstable, tends to lose balance spontaneously.

4 = unable to stand without assistance.

Treatment Procedures:

- All patients were evaluated at the beginning and at the end of the treatment program. Program of treatment was at the rate of one hour per day, three times per week for eight weeks.
- All patients received the traditional physical therapy program.
- The study group received in addition to the traditional physical therapy program a selected specific balance training program on the Biodex Stability System in the form of :

a- Static balance training:

The patient was instructed to grasp the hand rails and try to achieve a centered position on the platform. Once centering was achieved, the patient was instructed to keep the cursor directly in the middle of the screen.

b- Dynamic limits of stability training:

The patient was instructed to move the cursor to the box which appeared on the screen and then back to the center box again with little deviation as possible.

Statistical analysis

The arithmetic mean and standard deviation of the mean, the student paired t-test (to determine level of significance in one group pre and post treatment), and unpaired t-test between two groups (to determine level of significance between two groups). Level of significance was assumed at 0.05 for all analysis.

RESULTS

The current study was designed to investigate the influence of selected balance training program on Biodex stability system on postural instability of parkinsonian patient. The results of the present study before starting treatment revealed that there were no significant differences in all chronological variables (age, weight, length and duration of illness) between both groups (GI & GII). These results ensured matching between the patients in both groups. Therefore, it provided basis for comparison between results obtained. Mean value of age in G(I) = 56.27±5.97 years and G(II) = 57.87±6.74 years with (t=0.688, P=0.497). Mean value of Duration of illness in G(I) = 5.13±1.73 years and G(II) = 4.47±1.46 years with (t=1.143, P=0.263). Comparing the

mean of (OASI) in both groups (GI & GII) to normal age-matched subjects revealed that there was statistically significant impairment of postural stability in parkinsonian patients.

The results of this study showed statistical significant improvement in the study group. However non statistical significant difference in (OASI) in the control group as shown in table (1) and fig. (1).

Table (1): Effect of treatment procedures between the two groups on OASI, AP and ML stability index.

Group	Pre			Post		
	Mean ± SD			Mean ± SD		
	OASI	AP	ML	OASI	AP	ML
Study (I)	4.87± 0.66	3.41± 0.72	3.6± 0.74	2.72± 0.93	2.42± 0.69	2.21± 0.58
Control (II)	4.52± 0.71	3.65± 0.82	3.82± 0.65	4.39± 0.82	3.53± 0.87	3.71± 0.80
t-value	1.387	0.852	0.864	5.201	3.843	5.857
P value	0.176	0.40	0.395	0.0001***	0.0006***	0.0001***

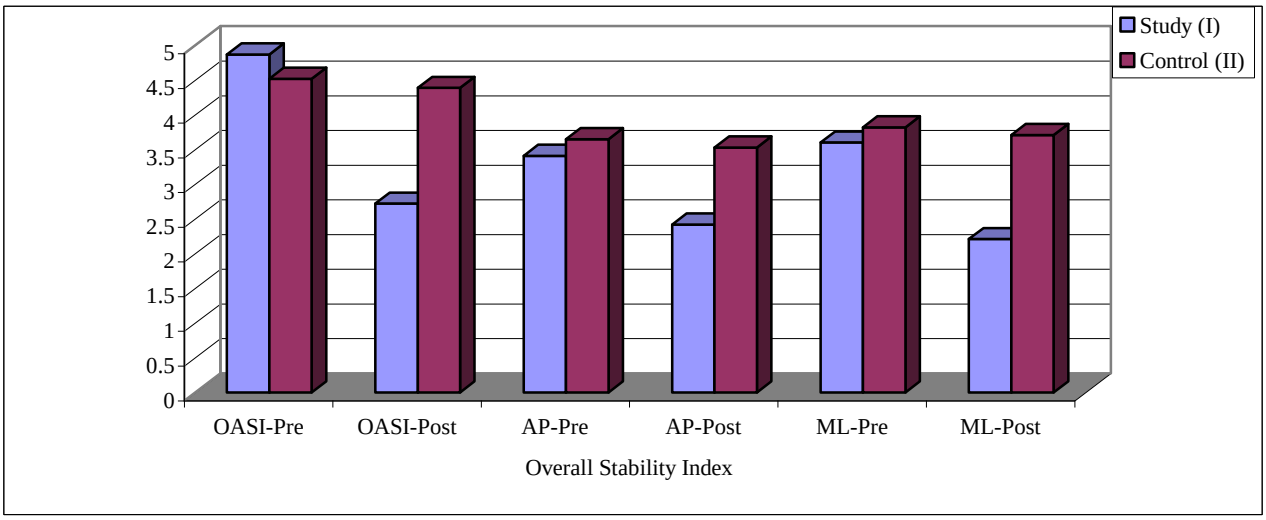

Fig. (1): Comparison between mean values of (OASI, AP and ML) in (GI) & (G II).

The results of this study showed statistical significant improvement in (DLOS) in the study group. However non statistical significant difference in (DLOS) in the control group as shown in table (2) and fig. (2).

Table (2): Effect of treatment procedures within each group and between the two groups on DLOS.

Group	Directional Control				Time			
	Pre	Post	t	P	Pre	Post	t	P
	Mean ± SD	Mean ± SD			Mean ± SD	Mean ± SD		
G (I)	13.47± 4.76	42.53± 9.06	16.85	0.0001***	221.4± 24.7	119.9± 38.15	13.21	0.0001***
G (II)	14.33± 3.85	16.27± 6.7	1.996	0.066	225.7± 21.54	220.3±32.71	1.77	0.098
t	0.548	9.046			0.512	7.74		
P	0.59	0.0001***			0.613	0.0001***		

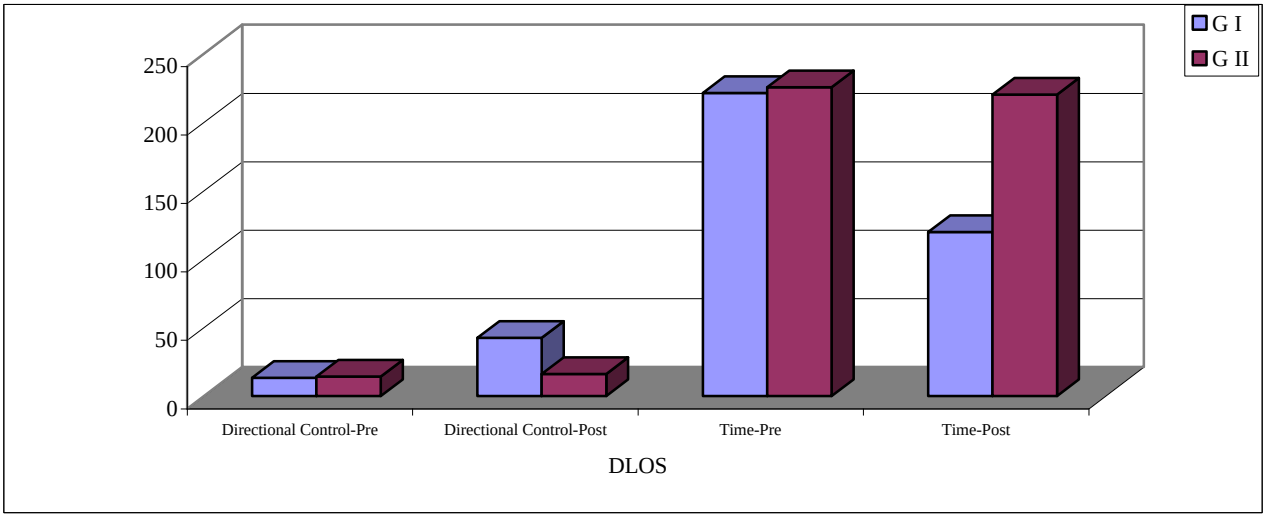

Fig. (2): Comparison between mean values of overall directional control and time pre and post treatment of both groups.

The results of this study showed statistical significant improvement in (BBS) in the study group. However non statistical significant difference in (BBS) in the control group as shown in table (3) and fig. (3).

Table (3): Effect of treatment procedures within each group and between the two groups on Berg balance.

Group	Pre	Post	t	P
	Mean ± SD	Mean ± SD		
Study (I)	38.2± 5.06	50.07± 6.64	8.019	0.0001***
Control(II)	40.27± 6.16	41.8± 8.61	1.921	0.075
t	1.004	2.944		
P	0.324	0.0064**		

The results of this study showed statistical significant improvement in (UPDRS) in the study group. However non statistical significant difference in (UPDRS) in the control group as shown in table (4).

Table (4): Effect of treatment procedures within each group and between the two groups on UPDRS.

Group	Pre	Post	t	P
	Mean ± SD	Mean ± SD		
Study (I)	2.53± 0.64	1.47± 0.73	4.675	0.0004 ***
Control(II)	2.47± 0.74	2.2± 0.68	1.00	0.334
t	0.263	2.83		
P	0.794	0.0086**		

DISCUSSION

The results of this study showed significant improvement in postural stability after training on the Biodex stability System in the study group and this can be explained by external sensory cues (visual, auditory cues, and proprioceptive stimuli) that could provide the necessary trigger in Parkinson's disease to switch from one movement sequence to the next and then bypass defective internal pallidocortical projections possibly via the later premotor cortex control of externally guided movements[9]. Patients with Parkinson's disease can generate normal motor patterns when they focus their attention on performance, that is, when they think on the execution of movements. By this way they activate the intact pre-motor cortex area and avoid relying on the impaired circuitry of the basal nuclei and assist in the production of movements. This result agreed with Cunnington (1995)[4], who revealed that Parkinson's disease can generate a normal gait pattern in presence of adequate regulatory sensory stimulation[4]. As the Biodex Balance System focuses on the proprioceptive neuromuscular mechanisms that appear to affect both static and dynamic balance. These mechanisms are responsible for the initiation of muscular responses that maintain postural stability[10].

This mechanism for bypassing the defective pallidoocortical projections with a visual rhythm could be similar to that for auditory cueing[14]. Connection from the visual system project via the lateral geniculate nuclei of the thalamus to the visual cortex and lateral pre-motor cortex where sensory information is received for externally guided movements[16,17]. Additionally alternative sensory visuo-motor circuit passing to the cerebellum and in particular the dentate nucleus may also be involved in the generation and/or guidance of movement based on visual cues[18]. Another explanation is that the external cue allows executive process to facilitate selective attentional process under frontal cortical control[7]. The need to select the correct response, initate the response and maintain initation through out the task is removed, which potentially free up attentiaonal resources[12].

Proprioceptive training may help in improving these patients' automatic motor responsiveness[24]. It provides a direct repetitive stimulus to the ascending tracts of the brain. Thus proprioceptive training could improves the reorganization process in which it strengths the synaptic activity. Practice provides more activation of brain areas resulting improvement of cerebral blood flow. The increase of blood flow in a particular area of the brain is thought to reflect a greater metabolic activity which results in increase of synaptic activity within that region[22].

In contrast, the control group results showed non statistical significant improvement after completing the study. This can be explained that the disease is a slowly deteriorating condition, assessment should be repeated over a long period to detect any change in performance. These results supported by Williams et al.(2006)[23] showed in the course of PD the tendency tends to invert and spontaneous body sway increases in all directions. In addition, automatic or voluntary postural adjustment mechanisms to external destabilizing perturbations become impaired in several ways: the amplitude of motor responses to spontaneous or induced instability is inappropriate, the sequence of these responses is altered and their delay is prolonged.

These results agree with Dibble et al.(2006)[5] who investigated how the

orientation and stabilization components of postural control may be affected as the result of the impaired proprioceptive integration possibly occurring in Parkinson's disease. Further more they suggested that proprioceptive impairment may be an important factor contributing to these patients' postural deficits. On the basis of their results, they recommended further strategies should be re-defined to compensate for the impaired proprioception integration.

REFERENCES

1- Adkin, A.L., Frank, J.S. and Jog, M.S.: Fear of falling and postural control in Parkinson's disease, Mov Disord., 18: 496-502, 2003.

2- Balash, Y., Peretz, C., Leibovich, G., Herman, T., Hausdorff, J.M. and Giladi, N.: Falls in outpatients with Parkinson's disease: frequency, impact and identifying factors. J Neurol., 252(11): 1310-1315, 2005.

3- Berg, K., Maki, B., Williams, J. and Holliday, P.: Clinical and laboratory measures of postural balance in an elderly population. Archives of Physical Medicine and Rehabilitation, 73: 1073-1080, 1992.

4- Cunnington, R., Iansek, R. and Bradshow, J.: Movement- related Potential in Parkinson's disease.Presence and predictability of temporal and spatial cues. Brain, 118: 935-50, 1995.

5- Dibble, L.E., Hale, T.F., Marcus, R.L., Droge, J., Gerber, J.P. and Lastayo, P.C.: High intensity resistance training amplifies muscle hypertrophy and functional gains in persons with Parkinsons's disease. Mov. Disord., 21: 1444-1452, 2006.

6- Fhan, S. and Eltan, R.: Devlopment of unified Parkinson's disease rating scale. In recent development in Parkinson's disease by Fahn, S., Marsden, C. and members of the UPDRS development committee. Florham Park; Macmillan health care information, 9: 153-163, 1997.

7- Gueye, L., Viallet, F., Legallet, E. and Trouche, E.: The use of advance for motor preparation in Parkinson's disease: Effects of cueing andcompatability between warning and imperative stimuli. Brain Cogn., 38: 66-86, 1998.

8- Guskiewicz, K.M. and Perrin, D.H.: Effect of orthotics on postural sway following inversion ankle sprain. J Orthop Sports Phys Ther., 23(5): 326-331, 1996.

9- Halsband, U., Ito, N., and Tanji, J.: The role pf promoter cortex and the supplementary motor aria in the Temporal control of movement in man. Brain, 116: 243-66, 1993.

10- Halsband, U., Matsuzakay and Tanji, J.: Neuronal activity in the primate supplementary, pre-supplementary and premotor cortex during externally and internally instructed sequential movements. Neurosci. Res., 20 : 149-155, 1994.

11- Johnson, R., Griffin, J. and McArthur, J.: Current therapy in neurological disease. Mosby-Elsevier, 7th ed, 281-288, 2006.

12- Konke, D., Taylor, A. and Saint, Cr.J.: The differential, effects of cueing on recall in Parkinson's disease and normal subjects. Brain Cong., 38: 261-274, 1998.

13- Maurer, C., Mergner, T., Xie, J., Faist, M., Pollak, P. and Lucking, C.: Effect of chronic bilateral subthalamic nucleus (STN) stimulation on postural control in Parkinson,s disease. Brain. 126: 1146-1163, 2003.

14- Mcintosh, G., Brown, S., Rice, R. and Thaut, M.: Rhythmic auditory- motor facilitation of gait patterns in patients with Parkinson,s disease. J., Neurosurg. Psychiatry, 62: 22-26, 1997.

15- Murphy, S.L., Williams, C.S. and Gill, T.M.: Characteristics associated with fear of falling and activity restriction in community-living older persons, J Am Geriatr Soc, 50(3): 516-520, 2002.

16- Mushiake, H. and Strick, P.: Preferential activity of dentate neurons during limb movement guided by vision . J. Neurophysiol., 70: 2660-2664, 1993.

17- Mushiake, H., Inase, M. and Tanji, J.: Neuroal activity in the primate premotor, supplementary, and precentral motor cortex

during visually guided and internally determined sequential movements. J. Neurophysiol., 66: 705-718, 1991.
18- Pincivero, D., Lephart, S.M. and Henry, T.: Learning effects and reliability of the Biodex stability system. Journal of athletic training., 30: 35, 1998.
19- Rozzi, S.L., Lephart, S.M., Sterner, R. and kuligowski, L.: Balance training for persons with functionally unstable ankles, JOSPT, 8: 478-486, 1999.
20- Stolze, H., Klebe, S., Zechlin, C., Baecker, C., Friege, L. and Deuschl, G.: Falls in frequent neurological diseases– prevalence, risk factors and aetiology. J Neurol. 251: 79-84, 2004.
21- Testerman, C. and Griend, R.: Evaluation of ankle instability using the Biodex stability system. Foot and Ankle Intentional., 20(5): 317-321, 1999.
22- Turton, A.: Mechanisms for recovery of hand and arm function after stroke: A review of evidence from studies during non-invasive investigative techniques. British journal of occupational therapy. 61: 359-363, 1998.
23- Williams, D.R., Whatt, H.C. and Lees, A.G.: Predictors of falls and fracture in pradykinetic rigid syndromes: a retrospective study. J Neurosurgery Psychiatry, 77: 468-473, 2006.
24- Yamamoto, Y., Struzik, Z.R., Soma, R., Ohashi, K. and Kwak, S.N.: Vestibular Stimulation Improves Automatic and Motor Responsiveness in Central Neurodegenerative Disorders, 102: 540-545, 2005.

الملخص العربي

فاعلية برنامج الاتزان التدريبي المختار على عدم الثبات القوامي عند مرضى الشلل الرعاش

أجريت هذه الدراسة بهدف دراسة فاعلية برنامج الاتزان التدريبي المختار على عدم الثبات القوامي لدى مرضى الشلل الرعاش . اختير لهذه الدراسة 30 مريضا من مرضى الشلل الرعاش وتراوحت أعمارهم ما بين 50 إلى 65 سنة ، قسموا إلى مجموعتين متساويتين . المجموعة الأولى (مجموعة الدراسة) عولجت عن طريق برنامج الاتزان التدريبي المختار مع برنامج التمرينات العلاجية التقليدي بينما عولجت المجموعة الثانية (المجموعة الضابطة) ببرنامج التمرينات العلاجية التقليدي فقط . وأستمر البرنامج العلاجي لمدة ثمانية أسابيع بواقع ثلاث مرات أسبوعيا . تم تقييم المرضى قبل وبعد العلاج عن طريق جهاز البيودكس ومقياس برج للاتزان ومقياس اليونيفيد المعدل لمرضى الشلل الرعاش . وأظهرت النتائج تحسن ذو دلالة إحصائية في الاتزان في مجموعة الدراسة عن المجموعة الضابطة مما سبق فانه يفضل استخدام برنامج الاتزان التدريبي المختار لتحسين عدم الثبات القوامي عند مرضى الشلل الرعاش .