The Impact of Visual Feedback Training on Postural Control in Chronic Mechanical Low Back Pain Patients

Gehan Mousa*, Amal Hassan and M.N. El-Bahrawy***
*Department of Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University.
**Department of Basic Sciences, Faculty of Physical Therapy, Cairo University.

ABSTRACT

The purpose of this study was to evaluate the influence of visual feedback program on postural control in mechanical low back pain patients. Thirty male patients with mean age of 38±1.00 years and twenty healthy subjects participated in this study. Patients were assigned into two equal groups. Both groups received hot pack on the lower back and exercises program for two months as four sessions per week. One group (G2) received additional visual feedback training using the Balance Master system. The ability to control the center of gravity over the base of support, gait and sit-to-stand parameters were assessed pre and post treatment for all groups. Intensity of pain was recorded pre and post treatment. The results revealed an improvement in back pain for patients groups while the improvement in postural control parameters was recorded in the second group. It could be concluded that the visual feedback training is a useful modality for improving postural control in patients with chronic mechanical back pain.
Key wards: *Back pain, postural adjustments, feedback training.*

INTRODUCTION

The term low back pain (LBP) refers to pain in the lumbosacral area of the spine encompassing the distance from 1st.lumbar vertebra to the 1st. sacral vertebra. The most frequent site of low back pain is in the 4th.and 5th.lumbar segment[31]. This is the area of the spine where the lordotic curve forms[2]. The low back, or lumbar area, serves a number of important functions for the human body. These functions include support, movement, and protection of certain body tissues. During standing, the lower back is functioning to hold most of the weight of the body[18].

The common cause of LBP is lumbar strain. A lumbar strain is a stretching injury to the ligaments, tendons, and/or muscles of the low back. The stretching incident results in microscopic tears of varying degrees in these tissues. The injury can occur because of over use, improper use or poor posture and can happen at any age[12,13]. The condition is characterized by localized discomfort in the low back area with onset after an event that mechanically stressed the lumbar tissues[30]. Postural sway increase in chronic LBP patients compared to healthy population[7,19,27]. This defect in postural control result from altered muscle control and proprioceptive impairment[22]. It has been demonstrated that components of postural control, such as postural stability and psychomotor speed, deteriorate in individuals with chronic LBP[1,15]. Moreover, clients with LBP can often present confusing symptoms that may be better explained by a functional as opposed to a structural deficit[16]. The purpose of this study was to evaluate the effect of physical therapy program and visual dependence on postural adjustment strategies in patients associated with LBP. This study focused on the importance of appropriately regulating feed forward and feedback postural control mechanisms.

SUBJECTS, MATERIALS AND METHODS

Subjects selection

Thirty male patients with mechanical LBP were recruited from the patients regularly refereed to outpatients physical therapy services –Prince Sultan Bin Abdul-Aziz Humanitarian City, as well as twenty weight, height and age matched healthy controls participated in this study. In addition, orthopedic and neurological consultants at the outpatient specialist clinic and the medical officer were given a description of the study, including its title, purpose, and subject inclusion and exclusion criteria. They were requested to refer suitable patients to the physical therapy department. The diagnosis of the patients was proved by plain x-ray and CT of the spine.

Inclusion criteria: All patients were male: 1) able to meet job demands but with back pain, their muscle strength of the lower limbs are within normal limits, 2) age between 20:45 years, 3) had recurrent LBP not less than three months prior to study procedures, 4) had no neurological signs, 5) had no pain on palpation and 6) had LBP as a primary complaint without leg pain.

Exclusion criteria: Patients were excluded if they: 1) were diagnosed as having spinal tumor, infection or inflammatory disease affecting the spine or disc prolapse, 2) had spinal or lower limb surgery, 3) had spinal fractures or structural deformities such as spondylolithesis and spondylosis, 4) had any contraindication to exercises therapy uncontrolled hypertension or diabetes mellitus or previous myocardial infarction, 5) had cerebrovascular disease, peripheral vascular disease, signs of nerve root compression confirmed by decreased tendon reflexes, sensory loss and myotomal deficits, 6) were receiving medications other than analgesics and non-steroidal anti-inflammatory drugs, 7) had long leg discrepancy, 8) had deformity (kyphosis, scoliosis, flat foot, etc), 9) had signs of benign vertigo, and/or 10) were receiving concurrent treatments from another practitioner for their back pain.

The healthy control group was medication free and had no active disease at the time of testing. All subjects should had good vision and signed the written informed consent.

Instrumentations

- The computerized Smart Balance Master system (Neuro Com International, INC, 9570, USA) with software version 8.2 was used to measure postural stability parameters in static and dynamic situations in both study and control groups and used also as a visual feedback training for the study groups. It is comprised of two 9M18 dual force plates. Each force plate is mounted on force transducers which measure vertical ground reaction force. Each force plate is connected to a monitor which displayed the operating instruction and give the subject continuous feedback via a video explanation and a moving cross. All test data were acquired and stored on 486 pc.
- Hot pack (ENRAF hot pack, al delft, Holland).

Procedures

The patients were assigned into two equal study groups (G1 and G2) using a randomized number sheet and compared to healthy control group (G3). All testing sessions were conducted at the same time of day to control for diurnal effect. The subjects were asked to were light clothes and avoid anxiety, emotional stress, exercises and eating (at least two hours) before conducting the procedures. The tests were administrated three times in a single session (with a five minutes rest interval) on three consecutive days and the mean values were calculated.

A- Evaluation protocol

- The subjects criteria including age, weight and height were recorded. * Visual Analogue Scale (VAS) was used to measure pain intensity in the study groups (G1&G2) pre and post treatment program. The patients were instructed to mark the VAS (1-100mm.)[25] to represent their pain intensity. A mark on the left of the scale indicated "no pain" whereas a mark on the far right indicated "unbearable pain". * Smart Balance Master testing: Laboratory evaluations of postural stability for all subjects(control and study groups) were done by using Balance Master System which include:

* Modified Clinical Test of Sensory Interaction on Balance (MCTSIB): The ability to control the COG (deg./sec.) over the base of support during various support surface (firm and foam) and visual conditions(static stability). The patient was asked to hold as still as possible with open and closed eyes, the amount of sway is expressed in degrees per second. Each task has three trails with eyes open, and three with eyes closed. The level of challenge was increased by altering the support surface from the firm level force plate to a foam pad.
* Functional abilities tests (dynamic balance control):

- Walk across: Step width (cm.), step length (cm.), and speed (deg./sec.).
- Sit- To- Stand (STS): Weight transfer time (sec.), rising index (force exerted to rise) and sway velocity (deg./sec.).

B- Treatment protocol:

The patients were classified randomly into two equal groups (G1 and G2), both groups received strengthening and stretching exercises program preceded by hot pack on the lower back. G2 received an additional visual-feedback balance training program by using Balance Master System. The treatment protocol was performed as four session per week for two months. Exercises program preceded by hot pack on the lower back for ten minutes.

* Strengthening exercises[33]:

- Leg raises to strength abdominal and hip muscles (from supine, one leg off the floor with holding for a count of 10, the contra lateral leg in flexion hip and knee).
- Partial sit-up to strength abdominal muscles (lie on back with bent knee, slowly raise head & shoulder).
- Back leg swing to strength hip and back muscles (stand behind chair lift one leg back and up while keeping knee extension repeat with other leg).
- Decrease strain on back muscles by standing with feet apart, place hands in lower of back and bend backward, hold for 1-2 second.

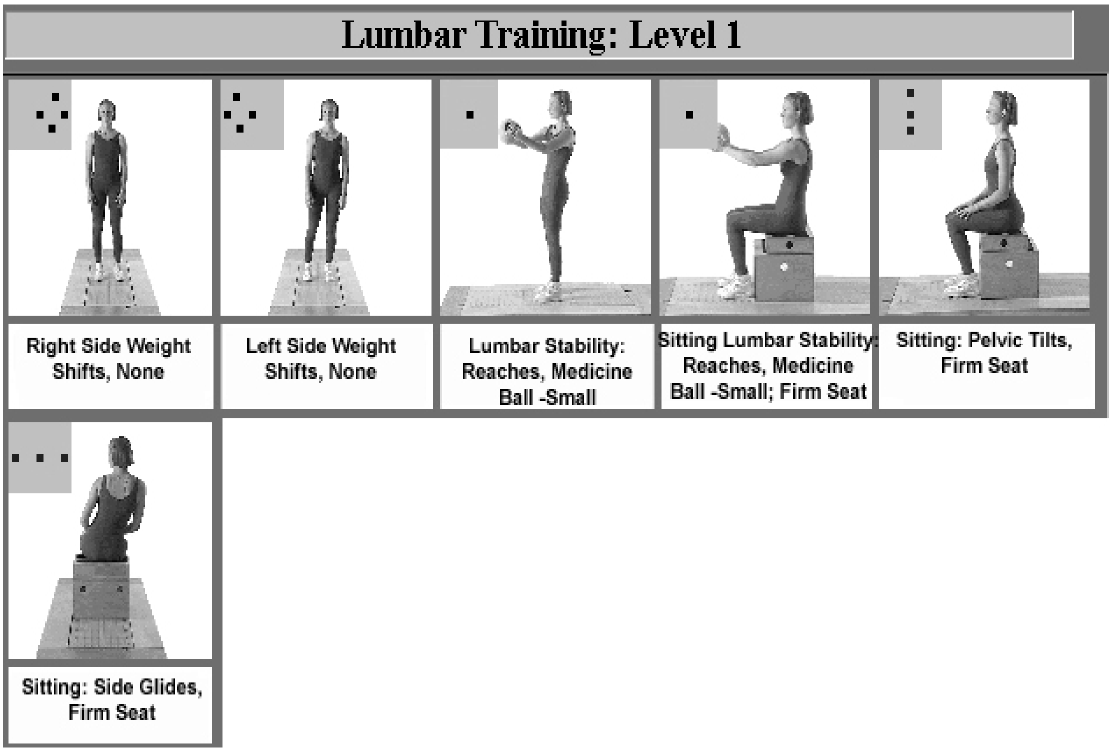
* Stretching exercises[8]:

- Back stretch: lying on back, slowly bring one knee to chest and grasp it with hand, hold for a count of three then Low relax, repeat with other leg.
- Extension stretch: stand with knee slightly bend, hand on back of waist and stretch backward while look to ceiling, hold for five second.
- Hamstring stretch: lying on back and supporting thigh behind knee, slowly straighten knee until a stretch is felt in the back of the thigh, hold ten seconds, repeat on each side.

* Balance training:

The treatment program was provided for an average of 30 minutes.

The patient was instructed to focus on the cursor to a blinking target. The patient started by trying to balance on the floor in the single leg stance (SLS) position with eyes open (EO) then he tried the other foot as a rhythmic weight shift. The step was repeated with eyes closed (EC). Then patient was instructed to stand on both feet with catching a medicine ball from standing and sitting positions (level 1&2). Next, progress from firm stability pads to foam standing with double stance and sitting with EO, then with EC followed by changing LOG within base of support (level 3 and 4). The patient followed the video instructions of the Balance system as a guide for each level of training before applying it (Fig. 1).



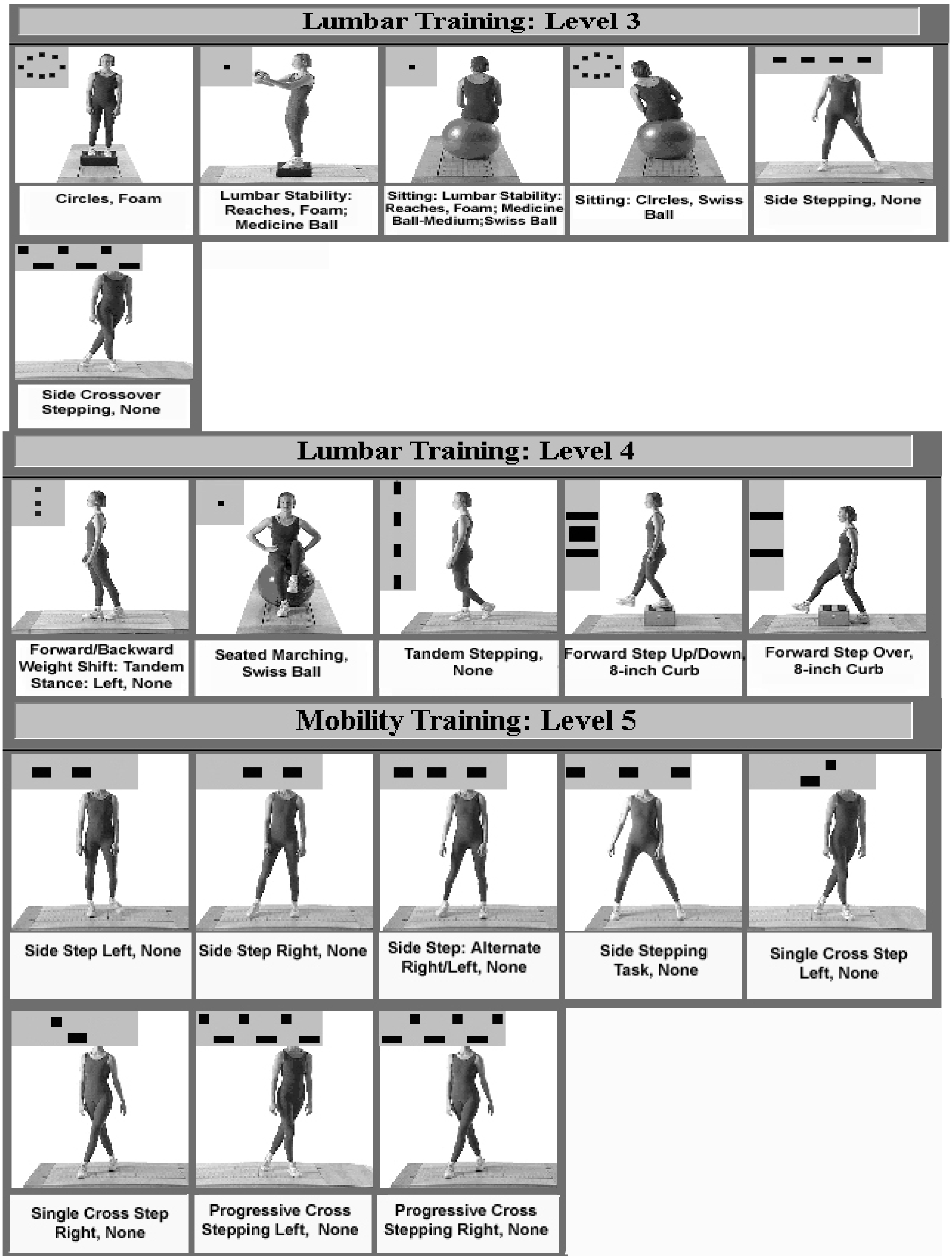


Fig. (1): Video illustration of balance training progression from level 1 to level 5.

Statistical analysis

Descriptive statistics in the form of mean and standard deviation were calculated for all variables. Student-test was used to compare variables within the study groups pre and post treatment program and independent t-test was used to compare between each two groups. Mann-Whitney U test was used to compare differences in pain values. Statistical significant was accepted at P<0.05.

RESULTS

The characteristics of patients (G1 and G2) and healthy control (G3) groups were represented in table (1). Inspection of the table revealed no significant differences in mean age, body weight and height among the three groups. There was no significant difference between patients group in pain intensity.

Table (1): The general characteristics of the three groups (G1,G2 and G).

	Age (years)		Weight (Kg.)		Height (cm.)		Pain intensity	
Group	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
G3	38	1.23	75.3	6.3	172.4	5.2	--	--
G1	37	1.32	78.8	4.7	170.6	6.7	71.00	8.50
G2	38	1.05	77.2	3.6	168.7	6.3	69.00	9.00
P-value	0.7		0.4		0.5		0.3	

Significance* at P< 0.05 SD= Standard deviation

The improvement in pain intensity described as the mean difference between the values obtained pre and post treatment according VAS (mm.). In the G1, the difference between the mean value pre and post treatment (71±8.5 & 34±9) was significant at P=0.004. In the G2, the difference was also significant (P=0.01) between the mean value pre and post treatment (69.00±9 & 31±8.5). The results revealed that LBP significantly reduced in both groups after treatment while there was no significant difference between both groups post treatment with P=0.93 (Table2).

Table (2): Improvement of back pain (VAS mm.) in both groups (G1 and G2).

	G1 Mean difference ±SD	G1 Mean difference ±SD	P-value
Pain intensity VAS%	37±8.00	38±74	0.93

Significance* at P< 0.05 SD= Standard deviation

Comparisons of static stability (deg./sec.) in the form of Modified Clinical Tests of Sensory Interaction on Balance (MCTSIB) between the three groups before treatment (G,G1 and G2) are presented in (Table 3) and illustrated in Fig. 2.

Table (3): Comparison between MCTSIB tests values(deg./sec.) pre treatment program in the three groups (G, G1 and G2).

	Firm surface		Foam surface	
	EO Mean ±SD	EC Mean ±SD	EO Mean ±SD	EC Mean ±SD
G3 G1	0.4 ±0.4 0.3 ±0.2	0.2 ±0.1 3.2 ±0.6	0.5 ±0.1 0.6 ±0.1	0.8 ±0.3 4.9 ±0.8
P- value	0.6	0.01*	0.9	0.02*
G3 G2	0.4 ±0.4 0.5 ±0.3	0.2 ±0.1 3.5 ±0.8	0.5 ±0.1 0.6 ±0.2	0.8 ±0.3 4.1 ±0.7
P- value	0.9	0.01*	0.5	0.04*
G1 G2	0.3 ±0.2 0.5 ±0.3	3.2 ±0.6 3.5 ±0.8	0.6 ±0.1 0.6 ±0.2	4.9 ±0.8 4.1 ±0.7
P- value	0.6	0.2	0.1	0.9

Significance* at P< 0.05 EO= eyes open EC= eyes closed

The results revealed a statistically significant difference between the control (G3) group and both study groups (G1 and G2) as regards to tests involved removal of vision (eyes closed) on firm and foam surfaces while there is no significant difference in relation to eyes open tests. There was no significant difference between G1 and G2 among the different tests.

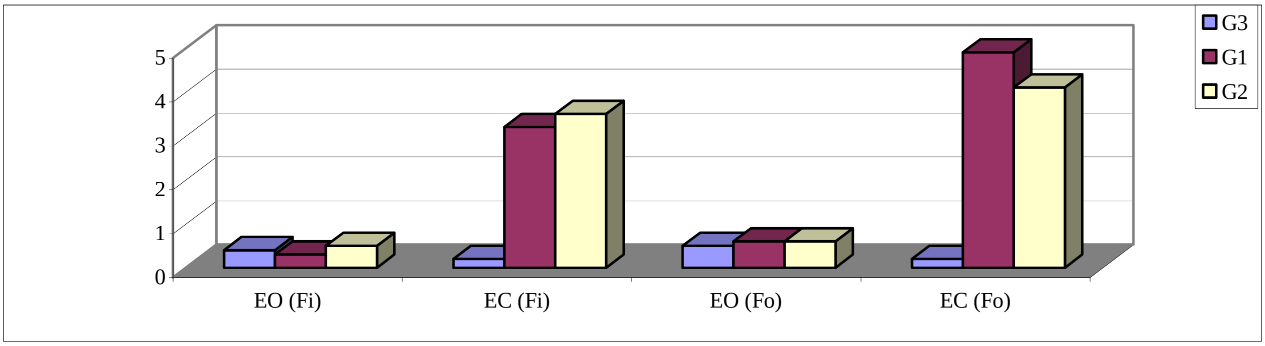


Fig. (2): Mean values of static stability with eyes open and closed (EO and EC) on firm and foam (Fi and Fo) surfaces among the three groups (G3, G1and G2).

Comparisons between values of static stability tests on firm and foam surfaces with open and closed eyes within the patients groups (G1 and G2) pre and post treatment are presented in (Table 4).

Table (4): Comparisons between mean values (deg./sec.) of MCTSIB tests pre and post treatment within study groups (G1 and G2).

	Firm surface		Foam surface	
	EO Mean ±SD	EC Mean ±SD	EO Mean ±SD	EC Mean ±SD
G1 Pre	0.3 ±0.2	3.2 ±0.6	0.6 ±0.1	4.9 ±0.8
G1 Post	0.3 ±0.3	3.0 ±0.1	0.4 ±0.2	4.0 ±0.6
P- value	0.8	0.1	0.6	0.5
G2 Pre	0.5 ±0.3	3.5 ±0.8	0.6 ±0.2	4.1 ±0.7
G2 Post	0.4 ±0.2	0.9 ±0.2	0.6 ±0.3	0.9 ±0.6
P- value	0.7	0.00*	0.9	0.01*

Significance* at P< 0.05 EO= eyes open SD= Standard deviation EC= eyes closed

The results revealed that there is no improvement in all tests with eyes closed and open on different surfaces (firm and foam) post treatment in the first group (G1) while the values of post treatment in relation to removal of vision (EC) in the second group (G2) were statistically increased (P=0.00&0.01).

Table (5): Comparisons between MCTSIB tests values (deg./sec.) post treatment program between the study groups (G1 and G2).

Surface	Mode of test	G1 Mean ±SD	G2 Mean ±SD	P-value
Firm surface	EO	0.3 ±0.3	0.4 ±0.2	0.5
	EC	3.0 ±0.1	0.9 ±0.2	0.00*
Foam surface	EO	0.4 ±0.2	0.6 ±0.3	0.9
	EC	4.0 ±0.6	0.9 ±0.6	0.01*

Significance* at P< 0.05 EO = eyes open SD=Standard deviation EC = eyes closed

The results of comparisons between patients groups (G1 and G2) post treatment revealed a statistical significant difference between both groups during eyes closed tests which indicate improvement in G2 post treatment (table 5 and Fig. 3).

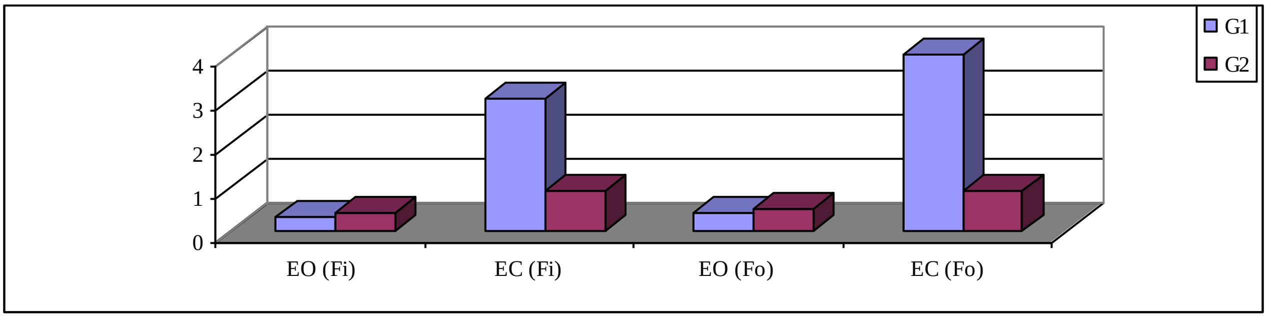


Fig. (3): Mean values of static stability with eyes open and closed (EO and EC) on firm and foam (Fi and Fo) surfaces between the study groups (G1 and G2).

Comparisons of gait parameters including step width (Sw), step length (SL), speed (S), transitional parameters of COG during raising from a seated position include weight transfer (Wt.T), raising index (RI) and sway velocity (SV) were quantified among the three groups pre treatment program (Table 6). There were a significant differences between control group (G3) and both study groups (G1 and G2) in all parameters while there was no significant difference between the two study groups (G1 and G2).

Table (6): Comparisons of gait parameters (Sw, SL and S) and sit to stand measurements (Wt., RI and SV) among the three groups (G, G1 and G2) pre treatment.

	Walk across			Sit-To- Stand		
	Sw (cm.)	SL (cm.)	S (cm/sec)	Wt. T %	RI (N)	SV (cm/sec)
G3 G1	10.9±3.8 15.6±3.9	58.6±10.9 38.3±5.1	73.8±8.8 59.0±4.7	0.6±0.1 1.8±0.1	14.6±2.6 8.0±2.5	2.1±8.0 14.0±7.0
P-value	0.01*	0.04*	0.00*	0.01*	0.00*	0.00*
G3 G2	10.9±3.8 15.4±3.8	58.6±10.9 39.3±4.5	73.8±8.8 60.0±6.8	0.6±0.1 1.5±1.5	14.6±2.6 7.8±3.7	2.1±8.0 12.6±9.2
P-value	0.01*	0.02*	0.00*	0.02*	0.00*	0.000*
G1 G2	15.6±3.9 15.4±3.8	38.3±5.1 39.3±4.5	59.0±4.7 60.0±6.8	1.8±0.1 1.5±1.5	8.0±2.5 7.8±3.7	14.0±7.0 12.6±9.2
P-value	0.7	0.9	0.2	0.2	0.5	0.3

Significance* at P< 0.05 cm = centimeter sec. = second Sw = Step width
Wt. = weight SL = Step length RI= raising index S = Speed Sv = sway velocity

Table (7): Comparisons of gait parameters (Sw, SL and S) and sit to stand measurements (Wt., RI and SV) within each group (G and G1) pre and post treatment.

	Walk across			Sit-To- Stand		
	Sw (cm.)	SL (cm.)	S (cm/sec)	Wt. T %	RI (N)	SV (cm/sec)
Pre G1 Post	15.6±3.9 10.42±4.5	38.3±5.1 42.6±2.3	59.0±4.7 52.1±6.4	1.8±0.1 1.4±1.2	8.0±2.5 7.2±1. 5	14.0±7.0 13±8.7
P-value	0.03*	0.12	0.24	0.26	0.87	0.67
Pre G2 Post	15.4±3.8 10.23±1.2	39.3±4.5 52.31±3.5	60.0±6.8 73.3±4.2	1.5±1.5 0.2±0.1	7.8±3.7 16.0±1.2	12.6±9.2 6.5±4.1
P-value	0.01*	0.02*	0.04*	0.00*	0.00*	0.000*

Significance* at P< 0.05 cm = centimeter sec = second Sw = Step width
Wt.=weight SL= Step length RI= raising index S = Speed Sv = sway velocity

Comparisons within each group (Table 7) revealed a statistical significant difference between pre and post variables (P<0.05) in the second group (G2) for all variables while there were no significant difference between pre and post variables in the first group (G1) except for the step width (Sw) as P=0.03. Pre values between both groups (G1 and G2) were compared and there were no significant difference between them (P>0.05) while comparisons of post values treatment showed a statistical significant difference between both groups (G1 and G2) with P-values<0.05 for all variables except for Sw (cm.) as P>0.05 (Table 8).

Table (8): Comparisons of gait parameters (Sw, SL and S) and sit to stand measurements (Wt., RI and SV) between both study groups (G and G1) post treatment.

	Walk across			Sit-To- Stand		
	Sw (cm.)	SL (cm.)	S (cm/sec)	Wt. T %	RI (N)	SV (cm/sec)
G1	10.42±3.8	42.6 ±2.3	52.1 ±6.4	1.4 ±1.2	7.2 ±1.5	13 ±8.7
G2	10.23±1.2	52.13 ±3.5	73.3 ±4.2	0.2 ±0.1	16.0 ±1.2	6.5 ±4.1
P-value	0.21	0.02*	0.01*	0.00*	0.00*	0.00*

Significance* at $P< 0.05$ cm = centimeter sec = second Sw = Step width
Wt.=weight SL= Step length RI= raising index S = Speed Sv = sway velocity

DISCUSSION

Postural control is the ability to maintain equilibrium by positioning the center of mass over the base of support which requires the use of postural adjustments[32]. Feed forward postural adjustments can be defined as specific functional changes in the position of the center of mass and of the body segments orientation which occur in preparation for an anticipated destabilizing force[23]. Feed back postural adjustments are elicited in response to unexpected destabilizing forces that result in threats to equilibrium[24].

The results of the present study showed that patients with mechanical back pain have poor postural control than healthy control subjects in relation to static stability tests and dynamic functional abilities. These findings were in agreement with prior researches which reported that balance measures not only provide a measure that discriminates between subjects with mechanical dysfunction and healthy people but also it reflect ability to perform every-day tasks of living[1,7,19,22,30]. Mok et al.,[20] concluded that Patients with non specific LBP have poor postural control on a short base which emphasized the utilization of the hip strategy for balance control. This disturbance in postural adjustments in subjects with mechanical LBP may be attributed to impairment in trunk control which compromise the control of trunk and hip movements[10,17,26]. Della et al.,[4] concluded that in chronic LBP, postural stability under challenging conditions is maintained by an increased postural sway. This may be due to altered peripheral proprioceptive system or the overall output of the postural system.

The primary finding of this study was that pain (VAS) was improved in both study groups (G1 and G2) after application of hot pack and exercises program. The results supported the findings of the previous studies[6,9] which proved that multimodal emphasizing exercises combined with hot pack are beneficial for chronic back pain as the ability to work differed significantly among these patients in comparison to no treatment group. Lewis et al.,[14] have shown that the exercises program intended to improve strength, pain, range of motion as well as reduced disability in questionnaire score. Tancred[34] demonstrated that exercises in combination with hot application is recommended to achieve a greater level of fitness in patients with low back pain. Muscle spasm is linked to pain as a protective measure. The consequence of muscle spasm cause tissue ischemia which may provoke further pain leading to a self- perpetuating cycle. Therefore, a reasonable expectation that the application of heat in addition to exercises would reduce pain and muscle spasm and so allow an increased range of movement.

Significant Increase in values of static stability tests in relation to eyes closed in the second group (G2) post balance training was observed while there was no improvement in the first group (G1). Reduction in the base of support in both groups was recorded in both groups after treatment program while other gait parameters (increase step length and speed) statistically improved in the second group after treatment. The parameters of sit to stand function were improved in the second group which received additional balance training compared to the first group after treatment program and there was no improvement in the first group.

These results agree with Ratzon and Froom[29] who mentioned that improvement in pain in nurses with present or past history of chronic back pain after physiotherapy program not include balance training is not associated with improvement of postural control measurements. The authors concluded that postural testing can predict the development of LBP or aid in determining appropriate preventive measures.

Moseley[21] postulated that therapeutic exercises that include proprioceptive reeducation demonstrated higher significant improvement in back pain, functional status and balance parameters. The findings support the efficacy of combined physiotherapy treatment in producing symptomatic and functional changes in moderately chronic low back pain.

The reeducation of postural adjustment and the integration of feedback postural rehabilitation are necessary for achieving balance recovery during treatment of non specific low back pain[3,29]. Exercises based on verbal, visual and tactile cues can normalize neural firing patterns that coordinates muscle activity to respond to both expected and unexpected forces[11]. Deyer and Miller[5] concluded that visual information training can compensate sensorimotor disturbance while the vestibular input is the only reliable reference when both vision and foot support are missing or unreliable.

Conclusion

Improvement in postural stability and functional abilities is enhanced in patients with mechanical back pain after applying specialized balance retraining program using visual feedback. These findings confirmed that the visual feedback is used to match and recalibrate proprioceptive sensory information or input that disturbed in chronic low back pain patients.

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الملخص العربي

تأثير الخلفية المرئية على سيطرة القوام في حالات ألام أسفل الظهر الميكانيكية

أجريت هذه الدراسة بهدف تقييم تأثير الخلفية المرئية على التوازن الساكن والحركي في حالات ألام أسفل الظهر الميكانيكية باستخدام جهاز ماستر للتوازن . اشتملت الدراسة على ثلاثين مريض (من الذكور) وتم مقارنتهم بعشرين من الأصحاء . تم تقسيم المرضى لمجموعتين كلا المجموعتين تم علاجهم ببرنامج خاص لتقوية العضلات واستطالتها بالإضافة لاستخدام الكمادة الساخنة على أسفل الظهر.وتم علاج المجموعة الثانية ببرنامج إضافي للتوازن باستخدام جهاز ماستر للتوازن وذلك لمدة شهرين بمعدل أربع جلسات أسبوعيا . تم تقييم شدة الألم ومقاييس التوازن السكن والحركي قبل وبعد العلاج.أسفرت النتائج عن تحسن ذو دلالة إحصائية في الألم في كلا المجموعتين.بالنسبة لقياسات التوازن فقد أسفرت النتائج عن فوارق ذات دلالة إحصائية بين المرضى والأصحاء وبين مجموعتي المرضى لصالح المجموعة الثانية مما يدل على إن استخدام جهاز ماستر للتوازن ذو الخلفية المرئية له تأثير واضح في تحسن الاتزان في حالات ألام الظهر السفلية الناتجة عن أسباب ميكانيكية.