Assessment of Postural Stability in Patients with Low Back Pain

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ABSTRACT

Purpose: *The purpose of the current study was to evaluate postural control in individuals withlow back pain (LBP).* ***Subjects:*** *Twenty eight adult subjects were included in this study. Fourteen normal subjects represented the control group and fourteen LBP patients represented the study group.* ***Methods:*** *Biodex stability system (BSS) was used to assess stability level in both control and study groups. Stability was measured in four conditions; bilateral and unilateral stance with eyes open and eyes closed over a period of 20s. Also patients' degree of functional disability was evaluated via Oswestry disability index (ODI).* ***Results:*** *The results revealed significant decrease in postural stability in LBP patients compared to that of the normal subjects. There was positive correlation between the degree of functional disability and the postural instability in the study group.* ***Conclusion:*** *Low back pain patients exhibited postural instability during standing.*
Key Words: *Low back pain - Biodex stability system - Oswestry disability index - Postural stability.*

INTRODUCTION

Low back pain is one of the most common and costly musculoskeletal complaints in today's societies, affecting up to 70-80% of the population at least one episode during their lifetime[33]. Many factors, such as lumbar spine stiffness; muscle shortening and weakness; and decreased muscle endurance, have been associated with LBP[19,20]. Several studies have indicated that patients with LBP showed reduced postural control that is commonly manifested in balance problem[15,32]. The maintenance and control of balance, whether under static or dynamic conditions, are considered as essential requirement for daily living activities[31]. Thus postural control variables have often been used to evaluate patients with various musculoskeletal or neuromuscular disorders[6,18]. Studies based on those systems have indicated that the maintenance of balance is a complex function involving major sensory and motor contributions[30].

Moreover, human postural system operates on the basis of integrated information from three independent sources: Vestibular, visual and somatosensory. These systems provide the neural input necessary to continuously adjust and correct body position in relation to the supporting surface and the surrounding environment[2,17]. The input from the three systems must be weighted relative to one another, through the central nervous system (CNS), depending on the immediate conditions. An important property of the postural control system is its ability to gate sensory input in accordance with the internal representation of the current posture, as to avoid undesirable responses triggered by external or internal perturbations[31]. An appropriate motor response requires an intact neuromuscular system and sufficient muscle strength to return the center of mass within the base of support when balance is disturbed[1].

Furthermore, balance or postural control is the ability to maintain equilibrium by positioning the centre of gravity (COG) over the base of support during quiet standing and movement[16,25]. The COG is the body's centre of mass and it changes according to changes in positions and movement of the body segment[34]. Postural adjustments occur in order to maintain equilibrium reactions. The equilibrium reactions are carried out by a complex process involving afferents from the sensory system, integration of the afferents by the CNS and the efferent's being sent from CNS to an intact musculoskeletal system[5]. It is conceivable that a derangement of any system (sensory, motor or CNS components) will influence the overall output of the postural control. The peripheral proprioceptive system or the central processing of proprioceptive information may be altered in chronic LBP[2,17].

Biodex stability system is a commercially available postural stability assessment and training system. It is designed to stimulate joint mechanoreceptors and to promote reflex muscular activation necessary for joint stability[35]. It has been used widely to evaluate postural stability in the recent years[3,4]. It is a multi-axial device that objectively measures and records an individual's ability to stabilize the involved joint under dynamic stress. Biodex stability system uses a circular platform that is free to move in the anterior–posterior and medial–lateral axes simultaneously. The BSS allows up to 20° of foot platform tilt, which permits the ankle joint mechanoreceptors to be stimulated maximally. It measures, in degrees, the tilt about each axis during dynamic conditions and calculates a medial–lateral stability index (MLSI), anterior–posterior stability index (APSI), and an overall stability index (OSI). These indices represent fluctuations around a zero point established prior to testing when the platform is stable. For example, an OSI of five degrees would be interpreted to mean that the displacement from the center is five degrees[3].

Aim of the study

The present study was conducted to test postural control during standing in patients with LBP.

SUBJECTS, MATERIALS AND METHODS

Twenty eight adult male subjects participated in this study. Fourteen volunteer normal subjects served as control group. Their age ranged from 30 to 45 years (mean = 33.5 ± 5.20 years), their weight ranged from 69 to 78 kg (mean = 72 ± 3.60 kg). Fourteen patients with LBP were selected from the out-clinic of physical therapy faculty, Cairo university and served as study group. They were examined by a physician to confirm their diagnosis. Their age ranged from 33 to 47 years (mean = 36 ± 5.2 years), their weight ranged from 71 to 80 kg (mean = 75 ± 2.43 kg).

Inclusion Criteria: All patients suffered from LBP for more than three months. Their history started with minimal discomforts that progressed to changes in daily activities as a result of back pain. **Exclusion Criteria:** History of orthopedic or vestibular problems. Neural tissue involvement such as nerve root entrapment, spinal cord compression, malignancy or lumber disc prolapse.

Instrumentation:

Biodex stability system: Biodex corporation, shirly, NY. It was used to measure postural stability under dynamic stress. A high score of MLSI, APSI and OSI indicates poor postural stability. The stability of the platform of the system can be varied by adjusting the level of resistance given by the springs under it. The platform stability ranges from 1–8, with one representing the greatest instability[5,16,25]. The system is interfaced with computer software and connected with Epson printer to print the test results[24].

Oswestry Disability Index: It was used with the study group to determine the degree of functional disability as a parameter indicating the functional level. It is a questionnaire consisting of ten items, every item ranges from zero to five points that are summated into a total score. The resulting points are divided on fifty and then multiplied by 100 to calculate the percent of disability. This scale evaluates the degree to which pain interferes with activities of daily living. Higher scores correlate with greater disability[13].

Procedures:

Subjects in both groups underwent the following steps of assessment:

Weight and height were measured to settle the matching in subject characteristics.

Functional disability level was evaluated by the ODI. The patient was asked to simply answer the questions of the scale by choosing the best answer that describes his typical pain and/or limitations within the last one or two weeks or two. If the patient limitations fall in-between two questions, he was asked to pick the higher point value question.

Stability level was evaluated by BSS. The subject was asked to center himself on the platform before starting the test. In this position, the COG of the body is centralized over a point of the vertical ground reaction force. He was then instructed to achieve a centered position on the released platform by shifting position of foot to keep cursor centered on the screen grid. The subject kept this position while investigator identified the subject's feet positions on the platform grid through recording the heel coordinates and feet angles. Heel coordinates were measured from the center of the back of the heel while the feet angles were determined by finding a parallel line on the platform coincided to the central line of the foot. All values were recorded on the balance system computer software to be used in each test to ensure the consistency of the tests to be performed in the same centered position[21]. The subject was then asked to assume and maintain upright standing position under the following test conditions: Standing on both feet with opened eyes, standing on both feet with closed eyes, standing on the dominant foot with opened eyes and standing on the dominant foot with closed eyes. All tests were done with the BSS at stability level of eight (most stable level). The subjects were instructed to maintain a level platform for a period of 20s for each test and rest by sitting for one min. Antero-posterior (AP) stability index and medio-lateral (ML) and overall stability (OS) index means of three trials were recorded for each condition in both the control and study groups.

Statistical analysis

Data were descriptively analyzed by calculating the mean and standard deviation. The independent student t-test was used to compare the mean stability level between the control and study groups. Pearson product-moment correlation coefficient test was used to correlate between the degree of functional disability and the level of postural stability in the study group.

RESULTS

Stability parameters during standing on both feet

Opened eyes: There was a significant difference in APSI mean values between control and study groups being 1.47 ± 0.23 and 2.73 ± 0.12 respectively. Also there was a highly significant difference in MLSI mean values between control group (1.39 ± 0.17) and study group (2.49 ± 0.13).

Closed eyes: There was a significant difference in APSI mean values between control and study groups being 2.26 ± 0.27 and 3.2 ± 0.18 respectively. Moreover, the MLSI mean values were significantly different between control group (1.96 ± 0.21) and study group (3.12 ± 0.12) (table 1and fig. 1).

Table (1): Comparison between mean values of A/P and M/L stability indices in the control and study groups during standing on both feet.

Variable	Open eyes				Closed eyes			
	A/P		M/L		A/P		M/L	
	Control group	Study group	Control group	Study group	Control group	Study group	Control group	Study group
Mean	1.47	2.73	1.39	2.49	2.26	3.2	1.96	3.12
SD	0.23	0.12	0.17	0.13	0.27	0.18	0.21	0.12
t-value	4.843*		5.05*		2.92*		4.76*	

A/P:Antero-posterior stability index
M/L: Medio-lateral stability index
*significant (P<0.05)

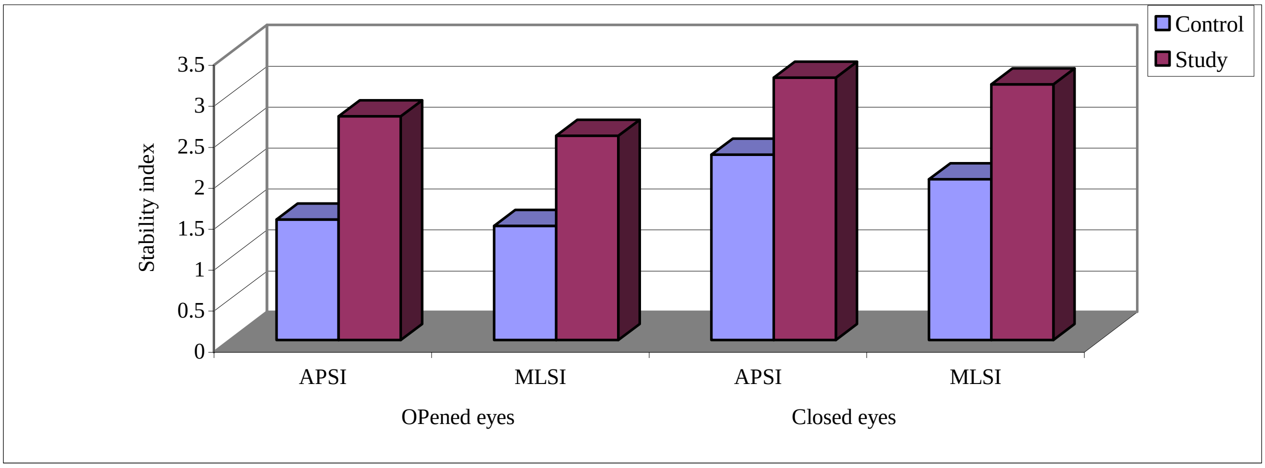

Fig. (1): The A/P and M/L stability index mean values in the control and study groups during standing on both feet with opened and closed eyes.

Stability parameters during standing on single foot

Opened eyes: There was a significant difference in APSI mean values between control group (1.60 ± 0.59) and study group (2.63 ± 0.87). Also, there was highly significant difference in the MLSI mean values between control group (1.55 ± 0.89) and study group (2.24 ± 0.73).

Closed eyes: The APSI mean values were significantly different between control group (2.06 ± 0.96) and study group (3.64 ± 0.67). MLSI mean values were also significantly different between control group and study groups being 1.97 ± 1.10 and 2.89 ± 0.93 respectively (table 2 and fig.2).

Table (2): Comparison between mean values of A/P and M/L stability indices in the control and study groups during standing on single foot.

Variable	Open eyes				Closed eyes			
	A/P		M/L		A/P		M/L	
	Control group	Study group	Control group	Study group	Control group	Study group	Control group	Study group
Mean	1.60	2.63	1.55	2.24	2.06	3.64	1.97	2.89
SD	0.59	0.87	0.89	0.73	0.96	0.67	0.10	0.93
t-value	4.973*		2.871*		6.368*		3.004*	

A/P: Antero-posterior stability index
M/L: Medio-lateral stability index
*significant (P<0.05)

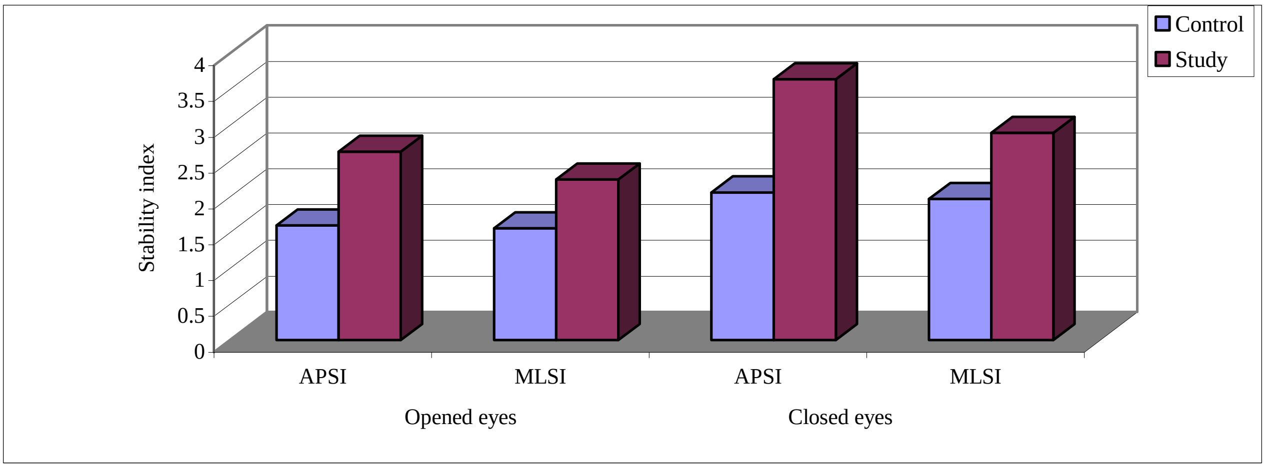

Fig. (2): The A/P and M/L stability index mean values in the control and study groups during standing on single foot.

Correlation between functional disability level and level of postural instability in the study group

There was a significant positive correlation between mean values of the level of functional disability assessed by ODI (46.55±12.19) and the overall stability index (OSI) measured by BSS (3.73 ± 0.19) in the study group (table 3).

Variable	Disability level	OSI
Mean± SD	46.55±12.19	3.73±0.19
r-value	0.4628*	

*significant (P<0.05)

DISCUSSION

In the present study, stability level was examined during four conditions ; standing on both feet with opened and closed eyes as well as standing on single foot with opened and closed eyes in both normal subjects (control group) and LBP patients (study group). The results revealed significant impairment in standing stability level tested in all conditions mentioned before in LBP patients compared to that of normal subjects. The findings also showed that there was significant positive correlation between the degree of functional disability evaluated by ODI and postural instability assessed by BSS. Consequently, it is clarified that impairment in postural stability is considered as an important problem facing LBP patients.

In the current study, BSS was selected to evaluate subject's postural stability because of its high reliability in stability testing. This is supported by other studies which reported that BSS to is a reliable assessment device for postural stability in healthy subjects[3,9,26]. Additionally, the ODI scale was selected to assess functional disability in LBP patients because of its validity as Fairbank and Pynsent[13] concluded that the ODI remains a valid and vigorous measure and has been a worthwhile outcome measure in patients with spinal disorders.

It was postulated that an appropriate motor response for postural control requires an intact neuromuscular system and sufficient muscle strength to return the center of mass within the base of support when balance is disturbed. Decreased muscle strength and proprioception in LBP patients compared to those without LBP have been shown in several studies. Muscle weakness and proprioceptive impairment has been suspected as one of the possible causes for balance impairments in patients with LBP[10,15,19,20]. This may affect the quality of sensory information and disrupt the relation between postural responses and sensory information[22,27]. In addition, Leinonen et al.,[28] reported that impaired muscle function, postural control, and lumbar proprioception have been observed in LBP.

In the present work, the significant difference in MLSI between normal subjects and LBP patients may be attributed to hip abductor weakness and imbalance in patients with LBP. This is agreed with the findings of Nadler et al.,[24] who stated that muscle imbalance in hip abductors is highly associated with LBP occurrence in athletes.

Also, the findings of the present study agreed with what was found by Radebold et al.,[28]. They found that patients with chronic LBP demonstrated poorer postural control and delayed trunk muscle response times than healthy control volunteers. They correlated between these two phenomena and suggested a common underlying pathology in the lumbar spine. Moreover, they found that average muscle onset times together with age and weight correlated significantly with balance performance with closed eyes but not with opened eyes. In addition, the results of the present research came in accordance with those of Mientjes and Frank[23] who concluded that there was increase in postural sway in chronic LBP patients as a group compared to healthy controls when the task involved increased complexity and removal of visual information.

Furthermore, limited range of motion of the lumber spine in patients with LBP could not explain the impaired postural control found in the current work. This is supported by Hamaoui and co-workers[14] who postulated that the center of pressure displacements increased significantly only in the antero-posterior axis in LBP, whereas there was a decrease in the range of motion only in the frontal plane. They concluded that postural sway in LBP could not be ascribed to the loss of spine range of motion, which represents the structural stiffening of the spine. So, the implication of the physiological factor of mobility i.e. an increase in active muscle tension, may impair the dynamic mobility capacity of the postural chain.

The results of the current work also agree with those of Dvir et al.,[11] who evaluated balance performance in both chronic LBP patients and control normal subjects. Balance was expressed in terms of body sway. Findings have indicated that LBP patients manifested significantly larger postural sway than control subjects in two out of the four unloaded tests and in all loaded tests. Absence of visual feedback as well as sinusoidal perturbations of the platform resulted in significant increase of sway in both groups. However, the magnitude of these increases was group dependent. It was concluded that chronic LBP patients present balance impairment which may be aggravated by external loading. They added that this finding may be attributed to reduction in endurance rather than strength of muscles in order to comply with the physiological requirements.

In addition, Bouche et al.,[7] studied postural sway in lumbar discectomy patients. They found significant increase in postural sway in lumbar discectomy patients compared with healthy controls especially in unilateral stance. They added that long-term following lumbar discectomy, there was no complete recovery of postural control. Patients develop visual compensation mechanisms for underlying sensory-motor deficits, which seem, however, sufficient only in case of pain relief.

Regarding the supraspinal level, Tsao et al.,[35] assessed postural control through onset of transverses abdominis muscle (TrA) EMG activity during single rapid arm flexion and extension tasks in LBP patients. Motor thresholds (MTs) for transcranial magnetic stimulation (TMS) were determined for responses contralateral and ipsilateral to the stimulated cortex. In addition, responses of TrA to TMS over the contralateral cortex were mapped during voluntary contractions at 10% of maximum. Their findings provided preliminary evidence of reorganization of trunk muscle representation at the motor cortex in individuals with recurrent LBP, and suggested that this reorganization was associated with deficits in postural control.

Finally, the significant positive correlation between the degree of functional disability and postural instability means that the outcome measurements of BSS is a good indicator to the severity of dysfunction in patients with LBP.

Conclusion: Patients with LBP have stability impairment and special concern should be given to balance training as a part of their rehabilitation program.

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الملخص العربي

تقييم الثبات الوضعي في مرضى ألم أسفل الظهر

الغرض : تهدف هذه الدراسة إلى تقييم درجة الثبات أثناء وضع الوقوف في المرضى الذين يعانون من ألم أسفل الظهر . **الأشخاص :** أُختير ثمانية وعشرين شخصا منهم أربعة عشر طبيعيون (مجموعة ضابطة) وأربعة عشر مريضا (مجموعة الدراسة) . **الطريقة :** تم تقييم درجة الثبات باستخدام جهاز البيوديكس وذلك أثناء أربعة حالات : الوقوف على القدمين معا ثم على قدم واحدة مع فتح العينين ثم مع غلقهما لمدة عشرون ثانية لكل حالة ، كما تم تقييم العجز الوظائفي عن طريق دليل أوسويسترى . **النتائج :** أوضحت النتائج فروق ذات دلالة إحصائية في درجة الثبات بين المجموعة الضابطة ومجموعة الدراسة في الحالات الأربعة ، كما أنه يوجد ارتباط إيجابي ذو دلالة إحصائية بين درجة الخلل في الثبات ودرجة العجز الوظائفي . **الاستنتاج :** يُستنتج من نتائج هذا البحث أن هناك خلل في درجة الثبات أثناء الوقوف في مرضى آلام أسفل الظهر .

الكلمات الدالة : ألم أسفل الظهر- جهاز البيوديكس للثبات - دليل أوسويسترى - الثبات الوضعي .