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ORIGINAL ARTICLE

Effects of lower back pain on postural equilibrium and fall risk during the third trimester of pregnancy

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Abstract

Objective: To evaluate the effects of lower back pain (LBP) on postural equilibrium and fall risk during the third trimester pregnancy period by comparing postural stability between pregnant with LBP and pregnant without LBP control women.
Methods: The study population comprised 68 women of 24–35 years in the third trimester of pregnancy. They were divided into Groups 1 ($n = 30$) and 2 ($n = 38$) according to the presence or absence of LBP, respectively. Postural stability were evaluated between groups using Tetrax Interactive Balance System posturography (Tetrax, Sunlight Medical Ltd, Tel Aviv, Israel) with eight sensory conditions.
Results: For eight different positions, pregnant patients with LBP showed significantly higher values of general stability index, Fourier transformation index (F1, F2–F4, F5–F6 and F7–F8) and fall index than controls.
Conclusion: LBP has a negative effect on postural stability. Postural equilibrium decreases and fall risk increases in pregnant patients with LBP.

Keywords

Equilibrium, lower back pain, pregnancy

History

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Introduction

Pregnant women are at higher risk of falling than non-pregnant women [1]. Although only 27% of women fall during pregnancy, 10% of these experience two or more falls [2], which can result in bone fractures, joint sprains, muscle strains, head injury, rupture of internal organs, internal hemorrhage, placental abruption and rupture of the uterus. These complications may threaten both maternal and fetal lives [3], warranting the identification of risk groups to prevent serious morbidities and mortality.

Pregnancy-related lower back pain (LBP) reflects relaxation of joints, heterogeneous weight gain, decreased neuromuscular control, decreased abdominal muscle strength and anterior shifts in the location of the center of the body. These are common and disabling problems and contribute to the risk of falling and postural instability [1]. Somatosensory impairments and musculoskeletal weakness have been suspected as possible reasons for poor balance in LBP. In addition to physical factors, LBP is influenced by psychological status such as emotional distress, which can increase LBP in pregnancy and during the postpartum period [4].

Several studies indicate that postural stability is decreased during pregnancy particularly during the third trimester [5–7]. However, factors that influence postural stability during pregnancy have not been demonstrated before. There are only two studies in the literature that investigated the influence of morning sickness and hyperemesis gravidarum on postural stability during pregnancy [8,9].

Low back pain that lasts <6 weeks is described as ''acute LBP''; 6–12 weeks is ''subacute LBP'' and >12 weeks is ''chronic LBP'' [10]. Several studies investigated postural control in chronic LBP populations [11–15]. Poor balance has been associated with musculoskeletal weakness and impaired somatosensory systems. However, postural control in patients with acute LBP has been investigated in only one study [16]. Moreover, the relationship between LBP and postural stability has not been examined in pregnant women, and no published studies demonstrate relationships with fall risks among patients with acute LBP. Thus, in the present study, we investigated the acute LBP on postural equilibrium and risk of falling during third trimester of pregnancy.

Methods

The study population comprised 68 women of 24–35 years in the third trimester of pregnancy. They were divided into Groups 1 ($n = 30$) and 2 ($n = 38$) according to the presence or absence of LBP, respectively. Comparisons of static postural

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stability were made between groups using Tetrax Interactive Balance System posturography (Tetrax, Sunlight Medical Ltd, Tel Aviv, Israel) with eight sensory conditions, as well as age, height, weight, gravity, parity, education level and job status were compared between groups. The study protocol was reviewed and approved by the university ethics committee, and all the participants gave written informed consent to participate in the study. Inclusion criteria for participants were as follows: pregnancy between 24 and 36 weeks, age of 24–35 years, height of 155–176 cm, weight of 65.5–100 kg, body mass index (BMI) between 25.0 and 34.9 kg/m^2 and LBP of <6-week duration.

Patients with multiple pregnancies, gestational diabetes mellitus, hypertension, pre-eclampsia, musculoskeletal or neurological abnormalities, a history of LBP prior to pregnancy, a history of surgery to lumbar or lower extremities, balance disorders, spinal deformities or rheumatic disease were excluded from the study.

Diagnosis of lumbar pain

Patients with lumbopelvic pain, which includes lumbar pain and pelvic girdle pain (PGP), were examined by a physical medicine and rehabilitation doctor, and standard histories of characteristics of lumbar pain and PGP were assessed. Subsequently, pelvic pain provocation tests (distraction test, posterior pelvic pain provocation test bilaterally, Gaenslen's test bilaterally, compression test and sacral thrust), active straight leg raising tests, neurologic examinations using the muscle strength, sensation and reflex testing for lower extremities, and the FABER test (Flexion, Abduction and External Rotation) were conducted. The differential diagnose of lumbar pain from PGP was done. The PGP criteria were two or more positive pelvic pain provocation tests. Lumbar pain was classified according to changes in pain and/or ranges of motion from repeated movements in various lumbar spine positions, or less than two positive pelvic pain provocation tests. Women were recorded as having no lumbopelvic pain if they had no subjective lumbopelvic complaints or less than two positive pelvic pain provocation tests and no lumbar effect from repeated movements [17,18].

Measurements of static postural stability

Static posturography was performed using the Tetrax system (Sunlight Medical Ltd, Tel Aviv, Israel), comprising computer software and a platform of four independent and integrated platforms (A, B, C and D) on an uncarpeted level floor with a handrail and a foam mat. Patients were instructed to place toes and heels on the four platforms (A, left heel; B, left toes; C, right heel and D, right toes), to extend their arms along the body, and to remain stable and still in the standing position for 32 s under each of the following sensory conditions. On a firm surface with face forward and open eyes looking at a target on the wall opposite to the platform (NO); on a firm surface with face forward and eyes closed (NC); on a firm surface with eyes closed and the head rotated at 45° to the right (HR); on a firm surface with eyes closed and the head rotated at 45° to the left (HL); on a firm surface with eyes closed and the head tilted at 30° backward (HB); on a firm surface with eyes closed and the head tilted at 30° forward (HF); on an unstable cushion surface with face forward and open eyes looking at a target on the wall opposite the platform, (PO) and on an unstable cushion surface with face forward and eyes closed (PC). The following parameters were evaluated using Tetrax posturography: stability index (SI), frequency bands of postural sway (F1, F2–F4, F5–F6 and F7–F8) and fall risk. The SI indicates overall stability and the capacity to make postural changes regardless of weight and height, and is assessed according to sway on the four platforms. Frequencies of postural sway were measured using Fourier transformation and were used to determine the intensity of postural sway within a spectrum of 0.01–3.0 Hz. The Tetrax system subdivides the postural sway spectrum into the following four frequency bands: low (F1), medium–low (F2–F4), medium–high (F5–F6) and high (F7–F8). Fall risk was expressed as a percentage and varied between 0 and 100 in analyses of Tetrax parameters under the eight conditions. Higher scores indicated a greater risk of falling with values between 0% and 36% considered as mild risk, values between 37% and 58% considered as moderate risk and values between 59% and 100% considered as high risk [19,20].

Statistical analysis

All data were analyzed using PASW Statistical software, version 18.0 (SPSS, Chicago, IL). The Kolmogorov–Smirnov test was used to determine if continuous variables were normally distributed. Descriptive statistics included mean ± SD and/or minimum–maximum values for continuous variables. Differences between mean and median values were identified using the Student's *t*-test and Mann–Whitney *U* test, respectively, and were considered significant when $p < 0.05$. For the multivariate analysis, the possible factors identified with univariate analyses were further entered into the logistic regression analysis with forward conditional method to determine independent predictors of patient outcome. Hosmer Lemoshow goodness of fit statistics were used to assess model fit.

Results

The mean (±SD) age in Group 1 (with LBP; $n = 30$) was 30.03 ± 3.80 and in Group 2 was 30.39 ± 3.13 (without LBP; $n = 38$). Demographic characteristics between groups were similar except for the abortus condition ($p = 0.045$) (Table 1).

Posturography assessments

Stability index

Group 1 had significantly higher SIs than Group 2 under all assessment conditions except for those of eyes open on a firm surface (NO), head front on a firm surface (HF) and eyes closed on a firm surface (NC). SIs of Groups 1 and 2 under the eight sensory conditions of the Tetrax are presented in Table 2.

Fourier index

Group 1 patients had significantly higher F1 values than Group 2 patients under NO, PO, HL and HF conditions. Group 1 patients had significantly higher F2–4 values than Group 2 patients under all eight conditions. Group 1 patients

Table 1. Demographic characteristics.

	Group 1 ($n = 30$) Average ± SD	Group 2 ($n = 38$) Average ± SD	p value
Age	30.03 ± 3.80	30.39 ± 3.13	0.669
Height (cm)	163.50 ± 4.96	165.84 ± 7.67	0.152
Weight (kg)	72.63 ± 9.17	75.97 ± 11.87	0.209
BMI	27.14 ± 3.02	27.65 ± 4.01	0.566
Gestational age (weeks)	31.46 ± 5.02	31.57 ± 4.45	0.923
Educational status			
Primary school	2 (6.7%)	0 (0%)	0.180
Secondary school	1 (3.3%)	0 (0%)	
High school	5 (16.7%)	11 (28.9%)	
University	22 (73.3%)	27 (71.1%)	
Job status			
Desk working	11 (36.7%)	21 (55.3%)	0.127
Non-desk working	19 (63.3%)	17 (44.7%)	
Parity			
1	20 (66.7%)	29 (76.3%)	0.379
2	10 (33.3%)	9 (23.7%)	
Abortus			
0	25 (83.3%)	34 (89.5%)	0.045*
1	5 (16.7%)	1 (2.6%)	
2	0 (0%)	3 (7.9%)	

*Significant difference from control values ($p < 0.05$).

had significantly higher F5–6 values than Group 2 under PO, PC, HL and HB conditions. Group 1 had significantly higher F7–8 values than Group 2 under PO, HR and HF. The postural sway frequency bands F1, F2–4, F5–6 and F7–8 for Groups 1 and 2 are compared under the eight sensory conditions of the Tetrax in Table 2.

Fall risk assessment

Group 1 patients had significantly higher fall indices (49.40 ± 24.47) in Tetrax analyses than Group 2 patients (28.47 ± 19.6) (Table 3).

Regression analysis of determinants of LBP during pregnancy

Regression analysis was used to determine relationships of LBP with demographic characteristics (age, height, weight, gestational age, educational status, job status, parity and abortus condition), the Tetrax balance parameters (SI, F1, F2–4, F5–6 and F7–8). Only F2–4 scores were significant risk factors for LBP during the third trimester of pregnancy ($p < 0.05$).

Discussion

The present cross-sectional clinical data indicate higher fall indices among pregnant women with LBP. The present LBP group had increased SI scores in all eight assessed conditions except the NO, NC and HF positions. Recent studies show that postural control may be impaired in patients with LBP compared to healthy subjects [11–15]. Moreover, somatosensory impairment and decreased muscle strength may lead disturbed balance in patients with LBP [16]. Although the mechanisms behind poor balance in patients with LBP remain unclear, Nies and Sinnot [12] showed that in comparison with healthy subjects, patients with LBP had increased postural sway on unstable surfaces and were unable to maintain their

Table 2. Comparison of scores for Fourier and stability indices in eight positions between groups.

	F1		F2–4		F5–6		F7–8		SI	
	Group 1 ($n = 30$)	Group 2 ($n = 38$)	Group 1 ($n = 30$)	Group 2 ($n = 38$)	Group 1 ($n = 30$)	Group 2 ($n = 38$)	Group 1 ($n = 30$)	Group 2 ($n = 38$)	Group 1 ($n = 30$)	Group 2 ($n = 38$)
NO	20.78 ± 13.64	14.57 ± 7.14	9.97 ± 4.53	8.04 ± 3.38	3.34 ± 1.84	2.79 ± 1.18	0.66 ± 0.30	0.56 ± 0.13	17.79 ± 4.44	15.83 ± 4.62
p value	0.028*		0.048*		0.140		0.080		0.083	
NC	21.93 ± 11.93	16.86 ± 10.33	12.40 ± 4.57	10.16 ± 3.45	4.18 ± 1.53	3.55 ± 1.34	0.79 ± 0.34	0.67 ± 0.16	23.08 ± 5.91	20.42 ± 5.00
p value	0.065		0.024*		0.078		0.051		0.093	
PO	24.50 ± 10.45	17.61 ± 7.10	11.36 ± 3.68	7.35 ± 2.88	4.23 ± 1.45	3.10 ± 1.03	0.80 ± 0.22	0.63 ± 0.15	21.55 ± 4.94	18.32 ± 4.79
p value	0.002*		0.000*		0.000*		0.000*		0.008*	
PC	28.98 ± 13.81	26.24 ± 12.74	15.53 ± 4.42	11.31 ± 5.14	5.99 ± 1.85	4.84 ± 1.35	1.05 ± 0.41	0.89 ± 0.23	31.31 ± 8.48	26.86 ± 6.13
p value	0.40		0.001*		0.004*		0.058		0.015*	
HR	20.52 ± 15.36	15.30 ± 9.07	11.48 ± 3.57	8.76 ± 3.45	4.05 ± 1.4	3.46 ± 1.17	0.78 ± 0.23	0.65 ± 0.17	22.85 ± 5.52	19.46 ± 4.58
p value	0.086		0.002*		0.064		0.008*		0.007*	
HL	23.63 ± 13.03	18.70 ± 8.12	11.10 ± 3.79	8.93 ± 2.39	4.33 ± 1.18	3.53 ± 0.88	0.84 ± 0.26	0.74 ± 0.16	23.43 ± 5.53	19.78 ± 3.62
p value	0.01*		0.005*		0.002*		0.052		0.002*	
HF	23.98 ± 12.15	16.61 ± 10.60	11.42 ± 3.09	9.21 ± 3.39	4.18 ± 1.21	3.66 ± 1.44	0.80 ± 0.19	0.69 ± 0.18	23.22 ± 5.53	20.74 ± 5.63
p value	0.01*		0.007*		0.116		0.024*		0.074	
HB	25.64 ± 9.23	20.97 ± 11.89	12.98 ± 4.08	10.13 ± 3.36	4.75 ± 1.29	3.56 ± 1.3	1.23 ± 2.05	0.76 ± 0.2	26.66 ± 5.87	22.31 ± 5.27
p value	0.082		0.002*		0.000*		0.164		0.002*	

*Significant difference from control values ($p < 0.05$). Data are given as mean ± SD.

Table 3. Comparison of scores for fall risk between groups.

	Group 1 ($n = 30$)	Group 2 ($n = 38$)	p value
Fall risk (%)	49.40 ± 24.47	28.47 ± 19.60	< 0.0001*

*Significant difference from control values ($p < 0.05$). Data are given as mean ± SD.

position while standing on one foot. In agreement, Hamaoui et al. [21] demonstrated that patients with LBP have increased postural sway in the anterior–posterior direction, and Mientjes and Frank [22] reported that chronic LBP causes increased mediolateral postural sway, particularly under conditions of restricted vision and complex tasks. Both the studies suggest improper proprioceptive inputs of the central nervous system (CNS) in patients with chronic LBP, and because proprioceptive receptors in the lumbar region are damaged, trunk muscle damage may also contribute to postural imbalance. Thus, impaired proprioceptive delivery and paravertebral muscle damage may impair postural stability [23]. In the present Tetrax analyses, the direction of postural sway was not evaluated. However, postural sway without direction can be evaluated according to SI scores. Thus, the present data are in agreement with those of the previous studies [12,21,23], and show increased SI scores among patients with LBP. In addition, these are the first data to show the effects of acute LBP on postural stability during pregnancy. Several studies show that the effects of LBP on postural stability are limited to chronic LBP, with only one study of acute LBP and postural stability showing that although static anterior–posterior instability was increased in the presence of acute LBP, dynamic balance was not affected [16]. This study suggested that postural consequences differ between patients with acute and chronic LBP, and individuals with acute LBP had normal functional hip and pelvic muscular functions, although abnormal activity of spinal muscles increased the anterior–posterior postural sway [16]. Sohn et al. [16] assumed that muscles of the trunk and lower extremities maintain balance under dynamic conditions, whereas trunk muscles are predominantly responsible for balance under static conditions, and suggest that whereas chronic LBP affects both dynamic and static stability, acute LBP primarily affects static stability. In the present study, static stability was disturbed in pregnant women with acute LBP, supporting the consideration of Sohn et al. As a limitation of this study, Tetrax cannot measure dynamic component of stability.

Since high Fourier indices at low frequency (0.01–0.1 Hz) may reflect poor vision of patients, we excluded patients with visual problems so that high F1 indices solely indicate increased postural sway. Given the increased effort required to maintain postural control during pregnancy, Fourier indices at low frequency in patients standing on pillows with their eyes open, or with the head to the front or left with eyes closed on firm surface were significantly higher than in control subjects. F1 scores were increased in the LBP group during standing on the pillow with eyes closed compared with those in the neutral eyes closed position, suggesting that somatosensory restrictions undermine balance control in pregnant women. Thus, the somatosensory system comprises an important compensatory mechanism that controls balance in women suffering from LBP during the third trimester of pregnancy. However, F1 scores were also increased in the standing with head front and left position indicating failure of the somatosensory system to completely compensate for balance impairments in pregnant women with LBP. Previous studies also indicate the effects of the visual system on postural stability in healthy pregnant women [7,24,25]. Specifically, Butler et al. [24] demonstrated an increased dependence on vision, and Oliviera et al. [7] showed decreased postural control in pregnant women standing on a reduced support base with eyes closed, and emphasized the compensatory effect of the visual system in later stages of pregnancy. In contrast, Nagai et al. [25] showed that pregnant women stabilize postural sway in the mediolateral direction by increasing sensitivity to somatosensory information from the lower half of body, indicating greater dependence on the somatosensory system than on visual and vestibular systems.

High Fourier indices at low–medium frequency (F2–4) indicate musculoskeletal fatigue and vestibular dysfunction. Since patients with vestibular disorders were excluded in this study, increased F2–4 indices may have reflected musculoskeletal fatigue. In addition, Fourier indices at low–medium frequency indicated significant differences in the LBP group under all the conditions. In recent studies, delayed action times and reduced muscular activities of the trunk (lumbar erector spina) and hip muscles (gluteus maximus) have been reported in patients with acute LBP [26,27]. Furthermore, due to poor posture, decreases in trunk muscle flexibility have been shown in patients with LBP [14]. In patients with acute LBP, erector spina and external oblique muscle activity decreases during the postural response process. Moreover, Hodges et al. [27] showed that erector spina muscle activity was decreased in patients with acute LBP. Thus, in agreement with recent studies, increased F2–4 frequencies may reflect decreased external oblique and erector spina muscle activity, although this requires confirmation with electromyography analyses in addition to Tetrax.

High Fourier indices at F5–6 frequencies indicate somatosensory disorders. Accordingly, significant differences were observed in the LBP group when standing on pillows with eyes open, reflecting a restricted somatosensory system, and when standing with eyes closed and head left or back, reflecting a restricted vestibular system. In patients with LBP, damage to lumbar regions alters the quantity and nature of proprioceptive inputs from muscle spindles, leading to improper proprioceptive inputs to the CNS and failure of responses to trunk positions and gravity [23].

Increased high frequency (F7–8) indices indicate a CNS dysfunction. In this study, F7–8 was significantly higher in the LBP group in the PO, HR, HF positions. Nonetheless, recent studies suggest that patients with LBP develop cognitive, musculoskeletal and somatosensory dysfunction [13]. Moreover, according to the ''limited capacity theory'' of attention, concurrent performance of two tasks results in competition that undermines performance of one or both of the tasks [13]. Decreased motor control and proprioception in individuals with LBP limits adaptation to unexpected stimuli. Under these conditions, cognitive systems have increased workload and respond inappropriately to the secondary cognitive task. Salavati et al. observed an effect of dual tasking on postural control in patients with varying degrees of LBP, but in accordance with observations by Mazaheri et al. [14], showed no differences between healthy individuals and patients with LBP [10]. In contrast, Sherafat et al. [13] showed that the effects of cognitive load on postural task performance depended on the difficulty of the task during dual tasking in individuals with chronic LBP. In agreement, Luoto et al. [15] reported slowed psychomotor speeds and short-term memory deficits in individuals with LBP. According to these studies, difficult postural tasks cause improper postural control responses [13,15]. Moreover, the present increases in F7–8 indices indicate that cognitive functions are affected in patients with LBP and lead to impaired postural stability.

There are a number of limitations in the current study that should be recognized. One of these limitations is the number of participants included. The same study protocol could be performed in a larger population. The second limitation is the third trimester pregnant patients were included. It is unknown whether the LBP also has the same effect on postural balance in first and second trimester pregnant patients, too. The third limitation is that stability in dynamic conditions was not measured. Further studies should be conducted to corroborate these findings.

In conclusion, to the best of our knowledge, this is the first study that shows pregnant women with LBP have higher risk of falling and postural instability than pregnant women without LBP. Diagnosing LBP in pregnant patients may have preventive and therapeutic effects. For example, maternal support belts should be used. Wearing high heeled shoes and carrying heavy items should be avoided. During antenatal periods, low back region strengthening and postural balance training exercises that can improve balance may be applied for prevention and treatment purposes.

Declaration of interest

The authors declare that there is no conflict of interest.

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