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ORIGINAL ARTICLE

Effects of lumbar stabilization and muscular stretching on pain, disabilities, postural control and muscle activation in pregnant woman with low back pain

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ABSTRACT

BACKGROUND: Low back pain is common during pregnancy. Lumbar stabilization and stretching exercises are recommended to treat low back pain in the general population. However, few studies have applied the effects of these two interventions in pregnant women with low back pain.
AIM: To compare the effects of lumbar stabilization and stretching exercises for the treatment of gestational low back pain.
DESIGN: A pilot randomized clinical trial.
SETTING: Laboratory of Functional Evaluation and Human Motor Performance and physical therapy clinics.
POPULATION: Initially, 30 pregnant women with low back pain were recruited, of which 24 met the following inclusion criteria: being between 19-29 weeks of gestation; being in prenatal clinical follow-up; having nonspecific mechanical low back pain started in pregnancy; not participating in specific low back pain treatment in the last 3 months. A total of 20 women completed the study (10 each group).
METHODS: The main outcome measures were clinical (pain by Visual Analogue Scale (VAS) and McGill Pain Questionnaire and disability by Roland Morris Questionnaire), and secondary outcome measures were: postural balance (force platform); muscle activation level of multifidus, iliocostalis lumborum, rectus abdominis and external abdominal oblique (electromyography). The women were randomized into two groups for 6 weeks of intervention twice a week for a 50-minute treatment: 1) lumbar stabilization exercise protocol and 2) stretching exercise protocol.
RESULTS: There was a significant reduction (P=0.03) in pain (1.68 in VAS and 4.81 for McGill questionnaire) for both interventions, but no change in disability score. In addition, both interventions were comparable for a significant improvement in postural stability (in mean d=0.77) for the velocity sway parameter, and significantly increased activation (P>0.05) of the external abdominal oblique muscle after intervention.
CONCLUSIONS: Both modalities (lumbar stabilization and stretching) were efficient for pain reduction, improving balance and increasing one trunk activity muscle after 6 weeks of intervention in pregnant women with low back pain.
CLINICAL REHABILITATION IMPACT: The present study has implications, especially for clinical decision-making with regard to therapy choice in pregnant women with LBP to reduce pain and improve trunk function as measured through balance performance.

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KEY WORDS: Low back pain; Pregnancy; Exercise; Postural balance; Electromyography.

Low back pain (LBP) is a frequent condition in pregnancy, which may begin early, but the maximum pain output is typically found during the third trimester.[1] This phenomenon can be explained in part by the morphological and biomechanical changes observed in pregnant women.[2] For example, skeletal muscles can adjust their structures/func-

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tions in response to the abdomen's increased size, and to the variation in the mother's hormonal environment. These adaptations may alter trunk segment kinematics, posture, balance, dynamic stability, flexibility, and muscle resistance to fatigue.[3] In addition, Panjabi's model[4] supports the relationship between LBP status and back muscle fatigue. In fact, trunk muscle fatigue may increase neuromuscular deficits, resulting in brief uncontrolled intervertebral movements and, consequently, may also increase spine instability resulting in tissue strain and in a cumulative effect of chronic low back pain.[4, 5] This can affect lumbar proprioception and balance control in some sub-group patients.[6]

A specific rehabilitation program and an increase in the level of physical activity can thus help to better manage LBP resulting from pregnancy and contribute to a better quality of life.[2] The main physical therapy interventions used for this condition are lumbar stabilization exercises (LSE) and stretching exercises (SE). LSE have gained popularity and credibility in this context[7] based on motor control of deep trunk muscles to develop better spine stability and in turn, reduce pain.[8] SE are encouraged by the American College of Sports Medicine (ACSM), to improving flexibility, muscle relaxation, and further contribute to balance performance while preventing musculoskeletal pain.[9] Some evidence supports SE as a treatment for LBP in pregnancy,[10] but no studies have compared their single effect *per se* using clinical, physiological and biomechanical outcomes. Positive results have already been described for both LSE and SE exercises for pain reduction in individuals with LBP.[8] However, this hypothesis has not been tested for pregnant women with LBP regarding specific clinical and functional outcomes, including biological and objective measures (such as balance and trunk activity using platform and electromyography signals, respectively).

The aim of this study was to compare the effect of these types of interventions (LSE × SE) for the first time in gestational LBP women, based on changes in pain, disability, postural balance and trunk muscular activity. Since prospective studies[11, 12] have suggested that back muscle endurance is an important clinical outcome, our hypothesis was that both interventions could improve function and decrease pain through exercise, but with superior clinical effects for LSE when compared to SE because of the stability model proposed for some sub-group patients.

Materials and methods

Design and participants

Initially, thirty pregnant women (aged >18 and <42 years) with reported gestational LBP were recruited for these studies, of which after clinical evaluation, six pregnant women were excluded for presenting chronic LBP prior to pregnancy, thus 24 pregnant women were randomized to both treatment groups (12 each). Throughout the study, there were four losses, two in each group, where the reasons for the losses were premature labor (N.=3) and pyelonephritis (N.=1). Recruitment for this randomized trial (ClinicalTrials.gov ID: NCT02933086) approved by the local ethics committee (CEP 1.579.189), was carried out in the local community through print and television media. This pilot trial was followed by the recommendations of the Consort statement[13] This study was conducted at the Center for Health Science Research at the Laboratory of Functional Evaluation and Human Motor Performance, and physical therapy clinics at the North Paraná University.

The inclusion criteria were: 1) being between 19 and 29 weeks of gestation; 2) being under prenatal clinical follow-up; 3) having nonspecific mechanical low back pain started in pregnancy; 4) not having or participating in specific treatment for LBP in the last 3 months; 5) being able to perform functional activities, and not presenting limitations in relation to cognition and attention; 6) signing informed consent for study participation. The exclusion criteria were inability to perform the proposed tests or showing any condition that indicated a high-risk pregnancy, red flags (*e.g.*: tumor, infection).

Power sample calculation

We used data from a previous (2012) study by França *et al.* to estimate the sample size needed to identify the differences between both types of interventions in LBP people (LSE *versus* SE).[8] Using BioStat software to estimate the sample size considering the mean differences between the LSE group (N.=15) and the SE group (N.=15) for pain outcome (5.88±1.3 *versus* 3.2±1.3, respectively), 11 participants would be needed per group to run an unpaired *t*-test (95% CI) between groups with a power of 0.80. We included an anticipated dropout rate of 10%.

Randomization as per CONSORT recommendations

Participants were informed about the possibility of being randomly assigned to one group or another. Participants were randomized in one of two treatment groups — a LSE group and a SE group. The randomization schedule was generated using the random.org website. The allocation schedule was printed on cards. These cards were sequentially numbered in opaque and sealed envelopes, each containing the name of one of the groups. The envelopes were selected by an external person who was not enrolled in the

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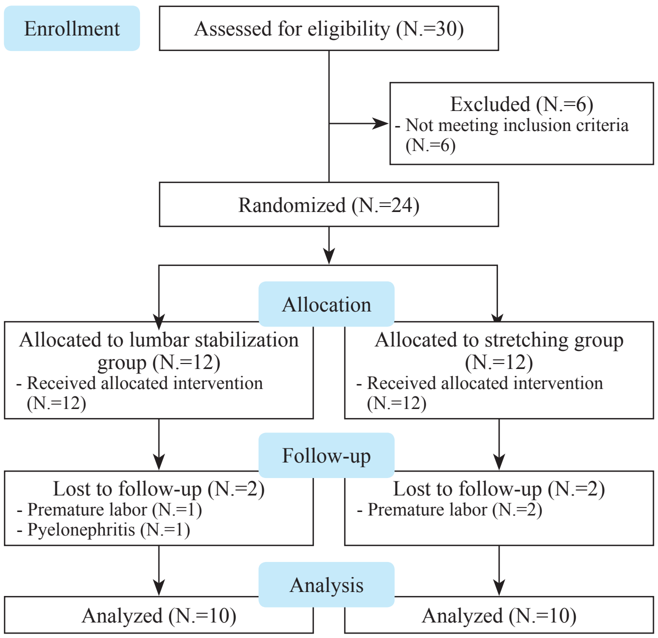

Figure 1.—CONSORT diagram illustrating the process from recruitment to data collection (6 weeks follow-up).

study. Due to the nature of the interventions, it was not possible to blind the subjects to the two types of exercise in the study. Figure 1 shows the design and flow of participants throughout the study.

Main outcomes

Based on our clinical and function study to compare the two interventions, the main outcomes were: pain and disability (clinical status), and secondary outcomes were: balance (force platform) and trunk activity (electromyography).

Instruments

Clinical evaluation

Clinical data were collected using a structured questionnaire with Personal Identification and Personal and Obstetric history. Pain was assessed using a pain point identification map, the Visual Analog Pain Scale (VAS) score,[14] and the McGill Pain Questionnaire (MPQ),[15] while for disability we used the Roland-Morris Disability Questionnaire (RMDQ).[16]

Force platform

A force platform (BIOMEC 400, EMG System do Brasil) was used for balance measures, in which the vertical ground reaction force was sampled at 100 Hz. All force signals from the platform were filtered with a 35-Hz low-pass second-order Butterworth filter, and converted into Center of Pressure (COP) using computerized stabilography analysis compiled with MATLAB routines (TheMathWorks, Natick, MA, USA). Stabilographic analysis of COP data led to the computation of main balance parameters: the 95% confidence ellipse area of COP (A-COP in cm^2), mean velocity (VEL in cm/s) in both anteroposterior (A/P) and mediolateral (M/L) directions of movement, and total displacement of COP (cm).[17]

Electromyography

Electromyography (EMG) signals were used to determine trunk muscular patterns during the performance of different balance exercises on a ball. EMG signals were collected from eight pre-amplified (gain: 1000) active surface electrodes (Model DE-2.3 Bagnoli; Delsys, Wellesley, MA, USA) at a sampling rate of 2000 Hz. EMG signals were subsequently bandpass filtered (20 and 450 Hz; eighth order zero-lag Butterworth IRR filter) to remove high-frequency noise as well as low-frequency movement and electrocardiography artifacts. A notch filter was also used for the EMG signals to remove frequencies at 60 Hz, and their harmonics.

The skin at the electrode sites was swabbed with alcohol and the electrodes positioned bilaterally on the multifidus at the L5 level (MU-L5-Left and MU-L5-Right), and on the iliocostalis lumborum at the L3 level (IL-L3-Left and IL-L3-Right), following the recommendations of Defoa *et al.*[18] with regard to muscle fiber direction (see details in da Silva *et al.*).[19] Four additional electrodes were positioned, bilaterally, over the external abdominal oblique (EAO-Left and EAO-Right) and rectus abdominis (RA-Left and RA-Right), following the recommendations of Vera-Garcia *et al.*[20] A reference (ground) silver-silver chloride electrode was positioned over the T8 spinous process.[19]

All EMG signals were processed and treated with MATLAB program routines (Version 11.0; The MathWorks Inc., Natick, MA, USA) to extract the electromyographic indicators of muscle activation, such as the amplitude of EMG signal in root mean square (RMS series 250 ms window-time).[14] First, the maximum EMG-RMS activity value during each balance sitting task on the ball (RMS_{PEAK}) was retained for each muscle. RMS_{PEAK} was then used as a reference to calculate muscle activation levels from a normalization procedure.[21] To determine average activity during the specific balance sitting task, the first 10 s of the task were analyzed to represent the mean activity (RMS_{TASK}). Both RMS_{PEAK} and RMS_{TASK} values were av-

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eraged across the three balance trials, as well as between left- and right-side muscles[21] to increase reliability and give a single value. The following equation was used to determine muscular activation level for all muscles and tasks:

$$EMG\%\ RMS = [(RMS_{TASK} / RMS_{PEAK}) \times 100\%]$$

The normalization of the EMG signal procedure from the peak of EMG amplitude calculated during a submaximal contraction as in the present study plays a role in reducing the inter-individual variability of data in each muscle group, mainly from a pathological sample, where pain and fear-avoidance of movement can be present as confounding variables associated with EMG measurement.[21, 22] Therefore, the procedure is valid, reliable, and supported by a recent study.[23]

Experimental protocol assessment

Balance upright task (using force platform measurement)

Two static upright balance postural tasks were performed randomly: two-legged stance either with eyes open (TLEO) or with eyes closed (TLEC). After familiarization, balance assessment was performed with a standardized protocol: Barefoot, with arms at the sides or parallel to the trunk. During testing with eyes open, the participant would look at a target (a cross) placed on a wall at eye level 2 m away. To prevent falls during testing, an investigator stood close to the volunteers during all tasks. For each balance condition, 3 x 30s trials with 30s rest intervals were performed and the mean was retained for analysis.[24] A landmark on the force platform was used to standardize foot positioning during all balance conditions.

Balance sitting task (using EMG measurements)

For trunk muscular activity evaluation, three balance sitting tasks on a Swiss ball were performed randomly, where the use of the ball is intended to provide an unstable surface, thus soliciting the trunk muscles during the dynamic postural control task. For each task, 3×10 s trials of trunk stability effort with 1 min rest intervals were performed. The tasks were: 1) to remain seated on the ball in a static position, with both feet resting on the floor and hands resting on the sternum (Balance Sitting Two Legs Static, BS-TLS); 2) sitting on the ball, raise the lower right leg off the floor and hold the lift for 10 seconds, with hands resting on the thighs (Balance Sitting Right Leg Elevate, BS-RLE); 3) sitting on the ball, raise the lower left leg off the floor and hold the lift for 10 seconds, with hands resting on the thighs (Balance Sitting Left Leg Elevate, BS-LLE). As previously mentioned, during testing, trunk EMG measurement was recorded during the tasks.

Clinical intervention

Planning and execution of both intervention proposals followed the guidelines of the American College of Obstetricians and Gynecologists (ACOG)[25] and the ACSM,[9] regarding duration, frequency, intensity and conditions for safe exercise in pregnancy. Composition of the proposed exercises was based on the systematic reviews carried out by The Cochrane Collaboration[1] and is illustrated in Figures 2 and 3.

After evaluation, each pregnant woman received the treatment for which she was allocated for six weeks, twice a week, and was reevaluated in the seventh week. Time for each session, in both protocols, was 50 minutes. The minimum acceptable frequency rate between the time of inclusion in the study and the sixth full week of intervention was set at 70%.

For progression in treatment protocols, pregnant woman were initially asked to do the minimum number of repetitions for each exercise, and throughout the sessions, as they mastered the tasks, ensuring their comfort and safety, progression was performed until the maximum number predicted for each exercise.

Pregnant women in the LSE group performed the entire protocol in an active manner, always individually assisted by a trained physiotherapist (Figure 2). Pregnant women in the SE group of exercises received treatment in a passive and individual way, in which a trained physiotherapist manually performed the protocol (Figure 3).

Statistical analysis

Categorical variables were described as absolute number and relative frequency, while numerical variables were described as mean and standard deviation (SD). The Shapiro-Wilk test was used to evaluate data normality. Student's *t*-test was used to compare differences between groups for anthropometric and clinical characteristics. A two-way mixed ANOVA was used to compare the two groups (LSE *versus* SE) and time effects (pre- and post-intervention), as well as the interactions themselves. Homogeneity of variances from these data was confirmed by Levene's test ($P>0.05$). We also calculated the mean differences between groups and times, with a 95% confidence interval (CI). The factor group was defined as a between-subject factor, while time was defined as a with-

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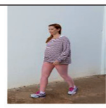
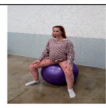
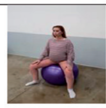
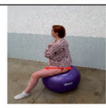
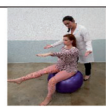
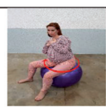
Exercise		Position
1. Warm Up		Light walk on circular path (4-8 min.)
2. Phasic perineum		In pelvic anteroversion position, sitting on swiss ball (2 sets of 8 rapid perineal contractions associated with exhalation)
3. Tonic perineum		In pelvic anteroversion position, sitting on the swiss ball (2 sets of 4 contractions, hold for 5 sec, associated with exhalation)
4. Pelvic synergism		Pelvic antero and retroversion movement sitting on swiss ball (4-8 repetitions, slow and associated with breath)
5. Trunk mobility		Association of trunk and head extension with inspiration and flexion with exhalation, sitting on swiss ball with hands resting on sternum (4-6 repetitions)
6. Scapular waist mobility		Association of shoulder posteriorization with inspiration and anteriorization with expiration, sitting on the ball (4-8 repetitions)
7. Balance		Contralateral upper and lower limb elevation simultaneously, for 5 sec, sitting on the ball (3-6 repetitions)
8. Slow pelvic swing		Slow circular pelvic motion sitting on the ball (4-8 repetitions)

Figure 2.—Description of the sequence of lumbar stabilization exercises (LSE).

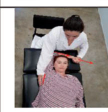
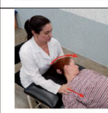
Muscles		Position
1. Tibial ischium		Lying on the surface, therapist elevates lower limb in extension and ankle dorsiflexion (3 x 20 sec repetitions, bilaterally and alternating)
2. Gluteus maximus		Lying on the surface, one lower limb in flexion and external rotation of the hip and knee flexion, and ankle resting on the contralateral thigh, therapist manually increases hip flexion toward the opposite shoulder (3 x 20 sec repetitions, bilateral and alternating)
3. Piriformis		Lying on the surface, one lower limb in flexion and external rotation of the hip and knee flexion, and ankle resting on the contralateral thigh, therapist manually performs hip adduction toward the opposite lower limb (3 x 20 sec repetitions, bilaterally and alternating)
4. Paravertebral		Sitting on the edge of a surface, abducted lower limbs and feet flat on the floor. With upper limbs propped on a Swiss grid ball, performs trunk flexion for freight and sideways (3 x 15 sec repetitions, bilaterally and alternating)
5. Quadratus lumborum		In lateral decubitus, therapist manually stretches the lumbar square (2 x 20 sec repetitions, bilaterally)
6. Latissimus dorsi		In supine position, upper limbs in 180° flexion, therapist manually lateralizes the pregnant woman's upper trunk to contralateral elongation (2 x 20 sec repetitions, bilaterally)
7. Scalene		In supine position, therapist performs cervical rotation and flexion to lengthen contralateral scalene (2 x 20 sec repetitions, bilaterally)
8. Trapezius		In supine position, therapist performs lateral tilt and cervical flexion to contralateral trapezius (2 x 20 sec repetitions, bilaterally)

Figure 3.—Description of the sequence of lower limb and trunk stretching exercises (SE).

in-subject factor. The effect size (*d*) was also calculated to determine the magnitude of clinical changes using Cohen's *d* classification: 0.20 to 0.49 for small, 0.50 to 0.79 for medium, and ≥0.80 for large.[26] All statistical analyses were performed with SPSS 20.0 for Windows (SPSS Inc., Chicago, IL, USA) with a significance level set at P<0.05. The intention to treat analysis was considered in the study.

Results

Both groups were homogeneous for gestational period, age and anthropometric characteristics (Table I; non-significant differences were reported between groups: P>0.05 from unpaired *t*-test). Significant pain reduction (P<0.05) was obtained after intervention for both groups from the VAS (*d*=0.29; with a reduction of 1.68 from the mean difference time in scale) and McGill pain questionnaire measures (*d*=0.29, with a reduction of 4.81 from the mean difference time). However, no significant group and time effect was reported to the disability variable, despite a range of 2 to 5.37 in 95% confidence interval (Table II).

Both groups improved their balance performance from postural control measurements (Table III) after both interventions, with most sensitive and significant (P<0.05) effects for the COP Velocity parameters in A/P (*d*=0.81) and in M/L directions (*d*=0.73) in eyes open condition, and in M/L direction (*d*=0.84) in eyes closed condition.

However, no group differences were found for all EMG muscles investigated during the three ball tasks (Table IV). The single effect was reported for the EAO muscle, which demonstrated a significant increase in activation across three tasks for both groups after intervention (time effect), with the effect size varying weak to moderate across muscles and tasks for both interventions (*d*=0.00 to 0.50).

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TABLE I.—*Baseline characteristics of pregnant women with low back pain.*

Characteristics	Stabilization (N.=10)	Stretching (N.=10)
Age, years	30±6	29±6
BMI pre, kg/m^2	23±2	26±3
BMI post, kg/m^2	25±2	28±3
Gestational age, weeks	23±3	23±3
Uterine fundus, cm	37±5	42±5
Abdominal circumference, cm	91±4	92±15
Pain duration, months	3.5±1.7	2.3±1.6
Primiparous	5 (50%)	8 (80%)
Occupation		
Housewife	4 (40%)	1 (10%)
Other occupation	6 (60%)	9 (90%)
Self-reported radiated pain	5 (50%)	4 (40%)
Physically active before pregnancy	4 (40%)	3 (30%)
Self-reported pain in rest	6 (60%)	6 (60%)
What makes pain worse?		
Seated position	3 (30%)	2 (20%)
Standing position	3 (30%)	1 (10%)
Maintain position for an extended period	0 (00%)	2 (20%)
Other	4 (40%)	5 (50%)
What makes the pain better?		
Rest	6 (60%)	5 (50%)
Other	4 (40%)	5 (50%)

Numerical variables are described as mean±SD, while categorical variables as (absolute) and relative frequency.
BMI: Body Mass Index.

Discussion

This study aimed to compare the effect of these types of interventions (LSE x SE) in gestational LBP women based on changes in pain, disability, postural balance and trunk muscular activity. We expected that both interventions could improve function and decrease pain from an exercise/action point of view, but with superior clinical effects for LSE when compared to SE because of the stability model proposed for some sub-group patients. Our first hypothesis was confirmed, but we cannot assume superiority of LSE over SE from clinical changes (effect size), despite the stability model based on the specificity of this type of exercise for the impaired lumbar region.[27] In our study, both modalities (lumbar stabilization and stretching) were efficient for pain reduction, improving balance and increasing one trunk activity muscle after 6 weeks of intervention in pregnant women with low back pain. The novelty of the present study has implications in scientific literature, especially for clinical decision-making in regard to therapy choice in pregnant women with LBP to reduce pain and improve trunk function, including balance performance.

Our main outcomes were clinical status including pain measurement. Both the VAS (1.87 pain scale reduction) and McGill questionnaire (4.81 score reduction) were sensitive enough to the effects of the two interventions in this population. Even with higher reduction for McGill when compared to VAS, both outcomes reported similar effect size (in mean d=0.29 across time), thus supporting the similarity between both interventions (Table II). Our results are consistent with previous studies based on these two modalities for pain reduction.[6, 28] The novelty of these results was thus based on the generalization of both interventions for low back pain management in pregnant on the principle of practical evidence-based physiotherapy.[29] However, even with a 1.68 reduction for disability, non-significant differences between groups and times (P>0.05) were found in both modalities of intervention. Considering previous studies[30] in which disability level worsened with the progression of gestation with LBP, regardless of interventions, the slight improvement found in our study can be considered as positive for the rehabilitation process, from a clinical point of view (even without statistical significance).

Regarding trunk function, evidence shows that pregnant LBP women generally have poor postural stability when compared to pregnant women without LBP.[31, 32] In fact, it is hypothesized that somatosensory impairments and musculoskeletal weakness from pain physio-pathological

TABLE II.—*Mean pain and disability scores of pregnant women with low back pain, for intervention groups and for pre and post intervention time.*

Variables	Timepoint	Intervention group		Group P value	95% CI	Time P value	Between-timepoint d
		Stabilization	Stretching				
VAS	Pre	3.9±1.6	5.4±2.2	1.00	-2.70 to 0.70	1.87	0.29
	Post	2.5±2	3±2.9	0.23		0.03*	
McGill	Pre	17±13.6	14±5.3	2.18	-10.45 to 6.07	4.81	0.29
	Post	11.3±8.5	10±3.4	0.58		0.03*	
RMDQ	Pre	10.1±5.3	12.7±3.8	1.68	-2 to 5.37	1.68	0.09
	Post	9.3±4.8	10.1±3.7	0.34		0.26	

VAS: Visual Analogic Scale; McGill: McGill Pain Questionnaire; RMDQ: Roland-Morris Disability Questionnaire.
*Significant difference (P<0.05) between pre and post times for both interventions.

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TABLE III.—*Mean of the postural control of the pregnant women with low back pain, with eyes open (EO) and eyes closed (EC), for intervention groups and for pre and post intervention time.*

Variables	Timepoint	Intervention group		Group P value	95% CI	Time P value	Between-timepoint *d*
		Stabilization	Stretching				
A-COP	Pre	3.69±3.53	2.75±2.04	1.06	-4.29 to 2.17	0.27	0.03
EO	Post	4.08±4.33	2.9±1.82	0.49		0.50	
VEL A/P	Pre	0.84±0.22	0.81±0.20	0.03	-0.21 to 0.13	0.60	0.81
EO	Post	0.24±0.24	0.20±0.22	0.66		0.001*	
VEL M/L	Pre	0.58±0.08	0.55±0.09	0.08	-0.17 to 0.00	0.28	0.73
EO	Post	0.35±0.18	0.21±0.10	0.06		0.001*	
A-COP	Pre	3.95±4.21	3.57±1.9	1.69	-3.08 to 2.74	0.50	0.10
EC	Post	3.24±2.63	3.28±1.9	0.90		0.23	
VEL A/P	Pre	1.07±0.23	4.81±10.8	1.84	-2.24 to 5.93	2.67	0.12
EC	Post	0.29±0.27	0.24±0.24	0.35		0.18	
VEL M/L	Pre	0.61±0.05	0.59±0.08	0.08	-0.17 to 0.00	0.303	0.84
EC	Post	0.38±0.16	0.23±0.10	0.06		0.001*	

A-COP: pressure center area; Vel A/P: anteroposterior velocity; Vel M/L: mediolateral velocity.
*Significant difference (P<0.05) between pre and post times for both interventions.

TABLE IV.—*Mean of the electromyographic signal of the pregnant women with low back pain, for intervention groups and for pre and post intervention times.*

Variables	Timepoint	Intervention		Group P value	95% CI	Time P value	Between-timepoint *d*
		Stabilization	Stretching				
EAO	Pre	33.51±6.92	30.56±5.90	2.38	-8.12 to 12.88	10.13	0.36
BS-TLS	Post	38.31±5.63	46.03±21.85	0.63		0.01*	
AR	Pre	27.07±4.34	26.32±4.51	0.10	-2.86 to 3.07	1.809	0.09
BS-TLS	Post	28.03±3.40	28.98±4.04	0.94		0.25	
MU-L5	Pre	37.69±7.84	43.87±11.93	1.06	-11.31 to 9.18	1.89	0.01
BS-TLS	Post	46.83±17.88	38.51±10.830	0.83		0.65	
IL-L3	Pre	38.99±6.62	35.96±9.25	9.57	-20.71 to 1.59	5.24	0.10
BS-TLS	Post	50.78±23.45	34.66±4.39	0.87		0.22	
EAO	Pre	31.40±6.14	30.96±9.13	2.44	-9.63 to 14.52	10.48	0.35
BS-RLE	Post	39.00±9.41	44.34±22.89	0.67		0.01*	
AR	Pre	27.02±4.68	26.33±5.25	0.14	-4.01 to 3.72	1.60	0.05
BS-RLE	Post	28.08±3.84	28.48±5.93	0.94		0.37	
MU-L5	Pre	34.92±4.85	37.87±14.09	0.600	-8.14 to 8.02	0.69	0.00
BS-RLE	Post	37.23±13.39	34.16±6.06	0.99		0.85	
IL-L3	Pre	35.42±8.26	34.16±8.59	8.79	-22.07 to 4.48	5.42	0.08
BS-RLE	Post	48.37±28.36	32.06±3.72	0.18		0.26	
EAO	Pre	31.07±6.42	33.20±9.19	5.28	-6.16 to 16.72	10.39	0.50
BS-LLE	Post	38.32±8.81	46.75±19.28	0.34		0.001*	
AR	Pre	25.68±5.74	26.34±5.05	0.56	-3.35 to 4.47	1.34	0.04
BS-LLE	Post	27.12±3.65	27.58±4.98	0.76		0.43	
MU-L5	Pre	32.85±10.32	37.90±10.79	2.42	-7.96 to 12.80	2.60	0.04
BS-LLE	Post	38.08±14.53	37.87±10.22	0.62		0.43	
IL-L3	Pre	35.69±6.70	33.91±6.70	6.37	-16.82 to 4.07	3.20	0.03
BS-LLE	Post	43.49±23.45	32.52±5.59	0.21		0.46	

EAO: external abdominal oblique; AR: abdominal rectus; MU-L5: multifidus; IL-L3: iliocostalis lumborum; BS-TLS: Balance Sitting Two Legs Static; BS-RLE: Balance Sitting Right Leg Elevate; BS-LLE: Balance Sitting Left Leg Elevate; LL: left leg; RL: right leg.
*Significant difference (P<0.05) between pre and post times for both interventions.

mechanisms are the possible reasons for poor balance in LBP,[33] and concluding that pregnant women with LBP are also at higher risk of falling compared to pregnant women without LBP.[34]

The present study reported an improvement in balance after both types of intervention, especially for the VEL postural control parameter (AP/ML eyes open). These results support previous studies,[34] although this study's

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experimental protocol is a first in scientific literature to determine outcomes in this particular set-up. The most important balance gains were evidenced in the direction of ML stability (under open and closed eye conditions), which can be explained by a physiological adaptation of pregnancy, where abduction and external rotation of the lower limbs causes an enlargement of the support base in the lateral direction, precisely for balance postural reactions and adjustments.[35] In addition, the positive effects associated with the LSE group suggests that this type of intervention contributes to the improvement of postural control based on the recovery of lumbar spine neuromuscular control when compared to a stability model. LSE strengthening exercises might improve these factors by stimulating coordination, motor control and spinal stability,[36] thus justifying the improvement of this measure after intervention.[37]

On the other hand, significant results in the SE group can be explained by the mechanical and neural factors related to stretching responses, since changes in joint range of motion cause decreased musculotendinous tension and pain,[38] improving the signal transmission between the central nervous and skeletal system.[39] In addition, literature mentions that repeated passive stretching decreases reflex activity resulting from reduced sensitivity of the neuromuscular spindle,[40] and improves joint positioning, pointing to a proprioceptive increase, which may explain the effects of stretching on balance.[41]

Finally, this is the first study to evaluate the effects of two interventions on the trunk activation. The results of the present study showed a significant increase in activation (10.39%) of the external abdominal oblique muscle after interventions in both modalities, with moderate effect size (d=0.50, Table IV). These results are supported by the literature on the subject. First, EMG changes after intervention could be due the pain adaptation model from pregnancy with LBP, as supported by Lund *et al.*[42] In fact, the pain adaptation model postulates that pain reduces the activation of muscles when acting as agonists, and increases the activation of muscles when acting as antagonists. This mechanism is related to the neural pathway mediating the recruitment changes with pain-adaptation from nociceptor action that projects on the alpha moto-neuron, via both inhibitory and excitatory interneurons.[43] Thus, the two interventions reduced pain, and could then mediate this mechanism of trunk activation more efficiently during the 6 weeks of treatment 2 x week. Although no intervention effect was pointed out for lumbar muscles, the significant increase in EAO muscle activation during all the requested tasks, in the comparison between pre and post-intervention time, in both LSE and SE, is very positive from a clinical perspective. It is hypothesized that neural adaptations could be mainly responsible for this change across six weeks of treatment.[44] Moreover, the gain in strength and flexibility for the trunk muscles is not only related to the physiological effects of one modality over another, in a short time-excursion of intervention (6 weeks versus 8 to 10 to 12 weeks, for example).[39] In fact, it is possible that both interventions also stimulate the improvement of viscoelastic properties in the muscle fibers through the repetition of movements performed during the two types of exercises,[8] which in turn may have conditioning benefits for trunk muscles in sensitive mechanical and physiological variables,[45] as found in the present study.

Our results show that both modalities can be considered for clinical interventions in the management of LBP in pregnancy. Furthermore, we assumed that these modalities may also prevent LBP during pregnancy, albeit modestly (9%), as pointed out by a recent meta-analysis.[46] In fact, 33% of gestational LBP cases persist for 12 weeks postpartum[47] and between 10% to 20% of women with chronic LBP state that the condition started during pregnancy,[6] thus suggesting that these modalities could be protective in an LBP context. Previous results reported that a treatment for LBP in pregnancy has repercussions for up to two years postpartum[7] and in subsequent pregnancies.[48]

Limitations of the study

Finally, this study has some limitations. First, the absence of a control group could increase relevance in the discussion section on a perspective for the best therapy in cases of gestational LBP. However, two intervention methods on one comparison are efficient for control: natural recovery, statistical regression, polite patients, placebo effects and recall bias. Another limitation was that we did not perform EMG measurements in the standing position, making it impossible to compare with the sitting posture on the ball. Another aspect is about the relatively small number of participants, given the difficulty in characterizing gestational LBP, and increase the variability from our data for some biological variables. This study cannot be generalized to pregnant women with chronic LBP (pre-gestational), but future studies comparing the two conditions (gestational LBP × chronic LBP) should be done. Further research may include a follow-up to assess the postpartum LBP status for up to 24 months.

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Conclusions

Our results indicate that both LSE and SE were efficient in reducing pain status from a clinical perspective measurement in pregnant women with LBP, but not affecting the disability level after 6 weeks of intervention. In addition, both modalities of exercise were positive to improve postural balance (based on a velocity COP sway measurement) and increase muscular activity of one important abdominal muscle after intervention (EAO muscle).

References

1. Liddle SD, Pennick V. Interventions for preventing and treating low back and pelvic pain during pregnancy. Cochrane Database Syst Rev 2015;(9).

2. Colla C, Paiva LL, Thomaz RP. Therapeutic exercise for pregnancy low back and pelvic pain: a systematic review. Fisioter Mov 2017;30:399–411.

3. Sklempe Kokic I, Ivanisevic M, Uremovic M, Kokic T, Pisot R, Simunic B. Effect of therapeutic exercises on pregnancy-related low back pain and pelvic girdle pain: secondary analysis of a randomized controlled trial. J Rehabil Med 2017;49:251–7.

4. Panjabi MM. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. J Spinal Disord 1992;5:383–9, discussion 397.

5. Granata KP, Gottipati P. Fatigue influences the dynamic stability of the torso. Ergonomics 2008;51:1258–71.

6. Parreira RB, Amorim CF, Gil AW, Teixeira DC, Bilodeau M, da Silva RA. Effect of trunk extensor fatigue on the postural balance of elderly and young adults during unipodal task. Eur J Appl Physiol 2013;113:1989–96.

7. Stuge B, Laerum E, Kirkesola G, Vøllestad N. The efficacy of a treatment program focusing on specific stabilizing exercises for pelvic girdle pain after pregnancy: a randomized controlled trial. Spine 2004;29:351–9.

8. França FR, Burke TN, Caffaro RR, Ramos LA, Marques AP. Effects of muscular stretching and segmental stabilization on functional disability and pain in patients with chronic low back pain: a randomized, controlled trial. J Manipulative Physiol Ther 2012;35:279–85.

9. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, *et al.*; American College of Sports Medicine. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 2011;43:1334–59.

10. Kluge J, Hall D, Louw Q, Theron G, Grové D. Specific exercises to treat pregnancy-related low back pain in a South African population. Int J Gynaecol Obstet 2011;113:187–91.

11. Biering-Sørensen F. Physical measurements as risk indicators for low-back trouble over a one-year period. Spine 1984;9:106–19.

12. Enthoven P, Skargren E, Kjellman G, Öberg B. Course of back pain in primary care: a prospective study of physical measures. J Rehabil Med 2003;35:168–73.

13. Schulz KF, Altman DG, Moher D; CONSORT Group. CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. BMC Med 2010;8:18.

14. da Silva RA, Vieira ER, Cabrera M, Altimari LR, Aguiar AF, Nowotny AH, *et al.* Back muscle fatigue of younger and older adults with and without chronic low back pain using two protocols: A case-control study. J Electromyogr Kinesiol 2015;25:928–36.

15. Menezes Costa LC, Maher CG, McAuley JH, Hancock MJ, de Melo Oliveira W, Azevedo DC, *et al.* The Brazilian-Portuguese versions of the McGill Pain Questionnaire were reproducible, valid, and responsive in patients with musculoskeletal pain. J Clin Epidemiol 2011;64:903–12.

16. Nusbaum L, Natour J, Ferraz MB, Goldenberg J. Translation, adaptation and validation of the Roland-Morris questionnaire—brazil Roland-Morris. Braz J Med Biol Res 2001;34:203–10.

17. da Silva RA, Vieira ER, Fernandes KB, Andraus RA, Oliveira MR, Sturion LA, *et al.* People with chronic low back pain have poorer balance than controls in challenging tasks. Disabil Rehabil 2018;40:1294–300.

18. De Foa JL, Forrest W, Biedermann HJ. Muscle fibre direction of longissimus, iliocostalis and multifidus: landmark-derived reference lines. J Anat 1989;163:243–7.

19. da Silva RA Jr, Arsenault AB, Gravel D, Larivière C, de Oliveira E Jr. Back muscle strength and fatigue in healthy and chronic low back pain subjects: a comparative study of 3 assessment protocols. Arch Phys Med Rehabil 2005;86:722–9.

20. Vera-Garcia FJ, Moreside JM, McGill SM. MVC techniques to normalize trunk muscle EMG in healthy women. J Electromyogr Kinesiol 2010;20:10–6.

21. Burden A. How should we normalize electromyograms obtained from healthy participants? What we have learned from over 25 years of research. J Electromyogr Kinesiol 2010;20:1023–35.

22. Oddsson LI, De Luca CJ. Activation imbalances in lumbar spine muscles in the presence of chronic low back pain. J Appl Physiol (1985) 2003;94:1410–20.

23. da Silva RA, Vieira ER, Léonard G, Beaulieu LD, Ngomo S, Nowotny AH, *et al.* Age- and low back pain-related differences in trunk muscle activation during one-legged stance balance task. Gait Posture 2019;69:25–30.

24. da Silva RA, Bilodeau M, Parreira RB, Teixeira DC, Amorim CF. Age-related differences in time-limit performance and force platform-based balance measures during one-leg stance. J Electromyogr Kinesiol 2013;23:634–9.

25. ACOG Committee Obstetric Practice. ACOG Committee opinion. Number 267, January 2002: exercise during pregnancy and the postpartum period. Obstet Gynecol 2002;99:171–3.

26. Cohen J. Statistical power analysis for the behavioral sciences. Routledge; 2013.

27. Waseem M, Karimi H, Gilani SA, Hassan D. Treatment of disability associated with chronic non-specific low back pain using core stabilization exercises in Pakistani population. J Back Musculoskeletal Rehabil 2019;32:149–54.

28. Chan EW, Adnan R, Azmi R. Effectiveness of core stability training and dynamic stretching in rehabilitation of chronic low back pain patient. Malays J Mov Health Exerc 2019;8:1–13.

29. Herbert R, Jamtvedt G, Hagen KB, Mead J, Chalmers I. Practical Evidence-Based Physiotherapy-E-Book. Elsevier Health Sciences; 2011.

30. Licciardone JC, Buchanan S, Hensel KL, King HH, Fulda KG, Stoll ST. Osteopathic manipulative treatment of back pain and related symptoms during pregnancy: a randomized controlled trial. Am J Obstet Gynecol 2010;202:43.e1–8.

31. Carvalho AP, Dufresne SS, de Oliveira MR, Beraldo FK, de Souza PA, da Silva RS, *et al.* Pregnant and non-pregnant women and low back pain-related differences on postural control measures during different balance tasks. Manual Therapy. Posturology & Rehabilitation Journal. 2019;17:755.

32. Öztürk G, Geler Külcü D, Aydoğ E, Kaspar Ç, Uğurel B. Effects of lower back pain on postural equilibrium and fall risk during the third trimester of pregnancy. J Matern Fetal Neonatal Med 2016;29:1358–62.

33. Sherafat S, Salavati M, Takamjani IE, Akhbari B, Rad SM, Mazaheri M, *et al.* Effect of dual-tasking on dynamic postural control in individuals with and without nonspecific low back pain. J Manipulative Physiol Ther 2014;37:170–9.

34. El-shamy FF, Ribeiro AP, Abo Gazia AA. Effectiveness of proprio-

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ceptive training on dynamic postural balance during pregnancy: A randomized controlled trial. Physiother Pract Res 2019;40:77–85.

35. Jang J, Hsiao KT, Hsiao-Wecksler ET. Balance (perceived and actual) and preferred stance width during pregnancy. Clin Biomech (Bristol, Avon) 2008;23:468–76.

36. Stevens VK, Coorevits PL, Bouche KG, Mahieu NN, Vanderstraeten GG, Danneels LA. The influence of specific training on trunk muscle recruitment patterns in healthy subjects during stabilization exercises. Man Ther 2007;12:271–9.

37. Boucher JA, Preuss R, Henry SM, Dumas JP, Larivière C. The effects of an 8-week stabilization exercise program on lumbar movement sense in patients with low back pain. BMC Musculoskelet Disord 2016;17:23.

38. Bae HI, Kim DY, Sung YH. Effects of a static stretch using a load on low back pain patients with shortened tensor fascia lata. J Exerc Rehabil 2017;13:227–31.

39. Fowles JR, Sale DG, MacDougall JD. Reduced strength after passive stretch of the human plantarflexors. J Appl Physiol (1985) 2000;89:1179–88.

40. Avela J, Kyröläinen H, Komi PV. Altered reflex sensitivity after repeated and prolonged passive muscle stretching. J Appl Physiol (1985) 1999;86:1283–91.

41. Costa PB, Graves BS, Whitehurst M, Jacobs PL. The acute effects of different durations of static stretching on dynamic balance performance. J Strength Cond Res 2009;23:141–7.

42. Lund JP, Donga R, Widmer CG, Stohler CS. The pain-adaptation model: a discussion of the relationship between chronic musculoskeletal pain and motor activity. Can J Physiol Pharmacol 1991;69:683–94.

43. van Dieën JH, Selen LP, Cholewicki J. Trunk muscle activation in low-back pain patients, an analysis of the literature. J Electromyogr Kinesiol 2003;13:333–51.

44. Rhea MR, Alvar BA, Burkett LN, Ball SD. A meta-analysis to determine the dose response for strength development. Med Sci Sports Exerc 2003;35:456–64.

45. El-Shamy FF, Ghait AS, Morsy M. Evaluation of postural stability in pregnant women. J Adv Med Med Res 2016;11:1–5.

46. Shiri R, Coggon D, Falah-Hassani K. Exercise for the prevention of low back and pelvic girdle pain in pregnancy: A meta-analysis of randomized controlled trials. Eur J Pain 2018;22:19–27.

47. Gutke A, Boissonnault J, Brook G, Stuge B. The severity and impact of pelvic girdle pain and low-back pain in pregnancy: a multinational study. J Womens Health (Larchmt) 2018;27:510–7.

48. Bogaert J, Stack M, Partington S, Marceca J, Tremback-Ball A. The effects of stabilization exercise on low back pain and pelvic girdle pain in pregnant women. Ann Phys Rehabil Med 2018;61:157–1.

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