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# Comparative efficacy of lumbar and pelvic support on pain, disability, and motor control in women with postpartum pelvic girdle pain: a three-armed randomized controlled trial

Fahimeh-Sadat Jafarian[1], Mahmonir Jafari-Harandi[2], Gillian Yeowell[3] and Ebrahim Sadeghi-Demneh[1*]

## Abstract

**Background** Pregnancy-related posterior pelvic girdle pain (PPGP) is a common cause of back pain and disability in the postpartum period. The objective of this study was to investigate the efficacy of orthotic support on pain, disability, and motor control in women with pregnancy-related PPGP.

**Methods** Eighty-four women with a clinical diagnosis of pregnancy-related PPGP participated in this randomized controlled trial (RCT). Participants were randomly allocated into three groups (with a ratio of 1:1:1): the pelvic support group, the lumbar support group, and the control group (patient-education leaflet). Pain severity, disability, effort during active straight leg raising test (ASLR), maximum isometric muscle force (hip flexion and trunk rotation), and joint position reproduction (JPR) of hip abduction were assessed as study outcomes. These variables were measured at four time points —before the intervention, immediately after the intervention, at the 4-week follow-up (at this time, the intervention period was terminated), and at the 5-week follow-up (one week after discontinuing the interventions)— to evaluate the possible effects of wearing support. Repeated-measures multivariate analysis of variance (MANOVA) was applied to determine the statistical significance between groups. Bonferroni post-hoc correction was used to identify significant differences between groups at different study time points.

**Results** There was a significant interaction effect for group × time for the study outcomes, including pain severity, disability, effort during ASLR, and maximum isometric muscle force between groups ($p < 0.001$), except JPR of hip abduction ($p = 0.13$). There were statistically significant differences in post hoc comparisons for pain intensity and effort during ASLR in lumbar support versus control condition and for maximum isometric muscle force in orthotic interventions versus control conditions immediately after the intervention ($P < 0.008$). Post hoc tests demonstrated statistically significant differences in orthotic interventions versus control conditions after 4-week and 5-week follow-ups ($P < 0.008$). None of the interventions significantly changed the JPR of hip abduction compared to the control group ($p > 0.008$). The effect sizes for study outcomes were large, except for the JPR of hip abduction.

*Correspondence:
Ebrahim Sadeghi-Demneh
sadeghi@rehab.mui.ac.ir

Full list of author information is available at the end of the article

**Conclusions** For women with pregnancy-related PPGP, both lumbar and pelvic supports were beneficial for decreasing pain and disability symptoms. Lumbar support showed better results for managing PPGP than pelvic support.

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**Keywords** Sacroiliac joint, Pain, Disability, Motor control, Lumbosacral orthosis, Postpartum

## Background

Pregnancy-related posterior pelvic girdle pain (PPGP) is one of the prevailing musculoskeletal conditions encountered during pregnancy and the postpartum period [1]. The prevalence of PPGP is approximately 30% after delivery [1]. The most common location of PPGP is between the posterior iliac crest and the gluteal fold, particularly near the sacroiliac joint [2]. The PPGP limits women's functioning in all domains according to the International Classification of Functioning, Disability, and Health (ICF) [3]. The endurance capacity of involved women for performing daily activities is also diminished [2]. PPGP can range from mild to severe and has been found to decrease tolerance for prolonged walking, sitting, or standing [4]. The exact mechanisms that lead to the development of PPGP remain unclear. Among many possible mechanisms, hormonal and biomechanical changes related to PPGP have been identified [2]. A weak association between relaxin levels and pregnancy-related PPGP has been found [5]. Therefore, physiological alterations in the mechanics of sacroiliac joints may play an important role in pelvic girdle pain [6].

The sacroiliac joint (SIJ) plays a key role in transferring loads between the spine and lower extremities [7]. Optimal SIJ stability is attained through form and force closure parameters. Form closure depends on the SIJ structure, whereas force closure is generated by the muscular system [7]. Effective form and force closures can control shear forces and stabilize the SIJ during load transfer activities [7]. During pregnancy, multiple factors have been shown to affect SIJ stability and potentially contribute to PPGP. A significant reduction in lumbopelvic muscle strength, reduced force closure, and increased maternal weight occur during pregnancy [8]. After delivery, there is an increased demand for activities such as lifting and carrying the baby, which requires normal motor control behavior. Poor motor control and muscle strength deficits at the lumbopelvic area result in increased shear forces through the SIJ and can ultimately cause pain and disability in the postpartum period [9, 10].

Early treatments could prevent functional impairment in the lumbopelvic region and disabiliy in women experiencing PPGP. Several noninvasive treatment options are used to reduce SIJ symptoms. Such interventions include strengthening exercises and lumbopelvic supports [11, 12]. Healthcare professionals recommend lumbopelvic support to relieve SIJ pain and improve comfort and function during the postpartum period [13]. The pelvic support is positioned caudal to the anterior superior iliac spine (ASIS) at the pubic symphysis level. The pelvic support applies external pelvic compression and can provide force and form closures, and neuromuscular control [14]. Lumbar support is similar to pelvic support regarding users' satisfaction, comfort, and pain reduction in people with back pain [15]. The lumbar support may decrease mechanical loading on the lumbopelvic muscles, improve force closure over a broader area compared to pelvic support, and enhance load transfer through the SIJs. Moreover, lumbar support enhances motor control, such as proprioception and muscle force, by stimulating a larger area of cutaneous mechanoreceptors compared to pelvic support [16, 17]. Therefore, it can be speculated that support may improve PPGP symptoms and motor control more effectively than pelvic support.

The majority of previous studies focus on the short-term results (such as immediate pain relief) without evaluating the lumbopelvic supports' long-term effects [13, 18, 19]. Further research is necessary to determine the orthoses' long-term effects on the PPGP symptoms' natural progression. There have been reports that some users may not use the lumbopelvic supports regularly because they feel uncomfortable or constricted [15]. This poor adherence could be underreported in the studies and lead to conflicting results in the literature on the benefits of lumbopelvic support in women with PPGP. Furthermore, the benefits of lumbopelvic support are often studied alongside exercise or physical therapy, making it difficult to determine the sole efficacy of lumbopelvic support [13, 18]. Further research on the advantages of orthotic therapy for women with PPGP is necessary in light of the aforementioned issues.

Despite numerous studies on pelvic support in pregnant women, there is a scarcity of research focused on postpartum women with PPGP. Furthermore, these studies focused only on the effects of pelvic support application on limited outcomes, so the generalizability of the results in promoting symptoms across women with PPGP remains to be determined. To our knowledge, no studies have investigated the efficacy of lumbar support for women with pregnancy-related PPGP. Thus, this study

aimed to examine the efficacy of lumbar support on pain, disability, and motor control in women with postpartum PPGP. The secondary aim was to explore the wash-out period following lumbar and pelvic support withdrawal. It was important to determine whether the effects of the lumbar and pelvic support on study outcomes are lasting or quickly revert to pre-intervention levels after removal. A one-week washout period was considered to assess the lasting impact of wearing pelvic and lumbar supports in this study. Studying the wash-out period is also essential for designing future crossover studies, ensuring proper switching of interventions and control of their possible carry-over effects.

## Methods

### Study design and participants

In this three-armed participant-blinded randomized controlled trial (RCT), participants were recruited from the obstetrics and gynecology clinic of the Isfahan University of Medical Sciences (IUMS), Isfahan, Iran. The examiner prescreened trial candidates with self-reported pregnancy-related PPGPs. Participants with self-reported pregnancy-related PPGP were considered for the trial if they had positive diagnostic tests, including the active straight leg raising test (ASLR), posterior pelvic pain provocation, the Gaenslen test, and the Patric-Faber test [20]. It is recommended to use these tests together, as a combination of the tests could address various biomechanical factors and pain responses related to pelvic girdle dysfunction [21]. Participants were subsequently assessed against both inclusion and exclusion criteria to determine their eligibility for the trial.

Inclusion criteria:

- Primipara women who experienced natural childbirth at least one month prior.
- Age between 18 and 45 years.
- A pain score of at least 40 out of 100 mm on the visual analog scale (VAS) [22].
- A score higher than 2 out of 5 on a 6-point Likert scale was given for perceived effort during the ASLR test on the painful side [23].

Exclusion criteria:

- The presence of lower back or pelvic pain before pregnancy.
- Limb length discrepancy.
- Neurological diseases.
- Congenital abnormalities in the spine, pelvis, and lower extremities.
- History of any fracture or surgery in the pelvis or lower extremities.
- Bilateral SIJ pain.

Enrollment in another investigative trial or using any other conservative treatment for pain relief during the study was not allowed. The Template for Intervention Description and Replication (TIDieR) checklist was used to ensure the standardized reporting of interventions within the trial protocol [24]. Informed consent was obtained from all the participants in the study, in accordance with the standards of the Declaration of Helsinki. This study adheres to CONsolidated Standards of Reporting Trials (CONSORT) guidelines.

### Assignment, randomization, and blinding procedures

Eligible participants ($n = 84$) were randomly assigned to one of three study arms with an allocation ratio of 1:1:1: pelvic (narrower) support ($n = 28$), lumbar (broader) support ($n = 28$), or control group (patient-education leaflet) ($n = 28$). No protocol changes were made during the trial. The examiner generated a randomization sequence with a block size of six using random allocation software (version 1.0, Saghaei M., Iran) to achieve balance in allocating participants to the study arms [25]. Whereas the examiner was aware of the allocation group, the participants were unaware of group assignments at the allocation point.

### Interventions

The interventions were described in the published study protocol [26] and are briefly outlined here. The pelvic support was an adjustable band (10–15 cm wide) secured with a Velcro strap just below the ASIS. (Fig. 1-A). The lumbar support consisted of a pelvic belt attached to the lumbar corset. Lumbar support had a 25 cm width anteriorly and extended from the xiphoid process to the pelvis. It had a 35 cm width posteriorly and extended from the thoracolumbar area to the gluteal prominences (Fig. 1-B). Participants in the intervention groups received lumbar or pelvic support. Each intervention was fitted and modified for participants by an orthotic practitioner, if necessary. The control group received only a patient education leaflet. Patients in the intervention groups were advised to wear support for at least 4 h per day over the 4-week intervention period and then stop wearing support for one week. All participants were instructed to pursue daily activities as usual. They received personalized feedback and support from a certified orthotic practitioner by phone in case of technical issues.

### Measures

The participants were assessed in the gynecology clinic at four time points: before the intervention (baseline), immediately after the intervention, at the 4-week follow-up (at this time, the intervention period was terminated), and at the 5-week follow-up (one week after discontinuing the interventions) to evaluate the possible

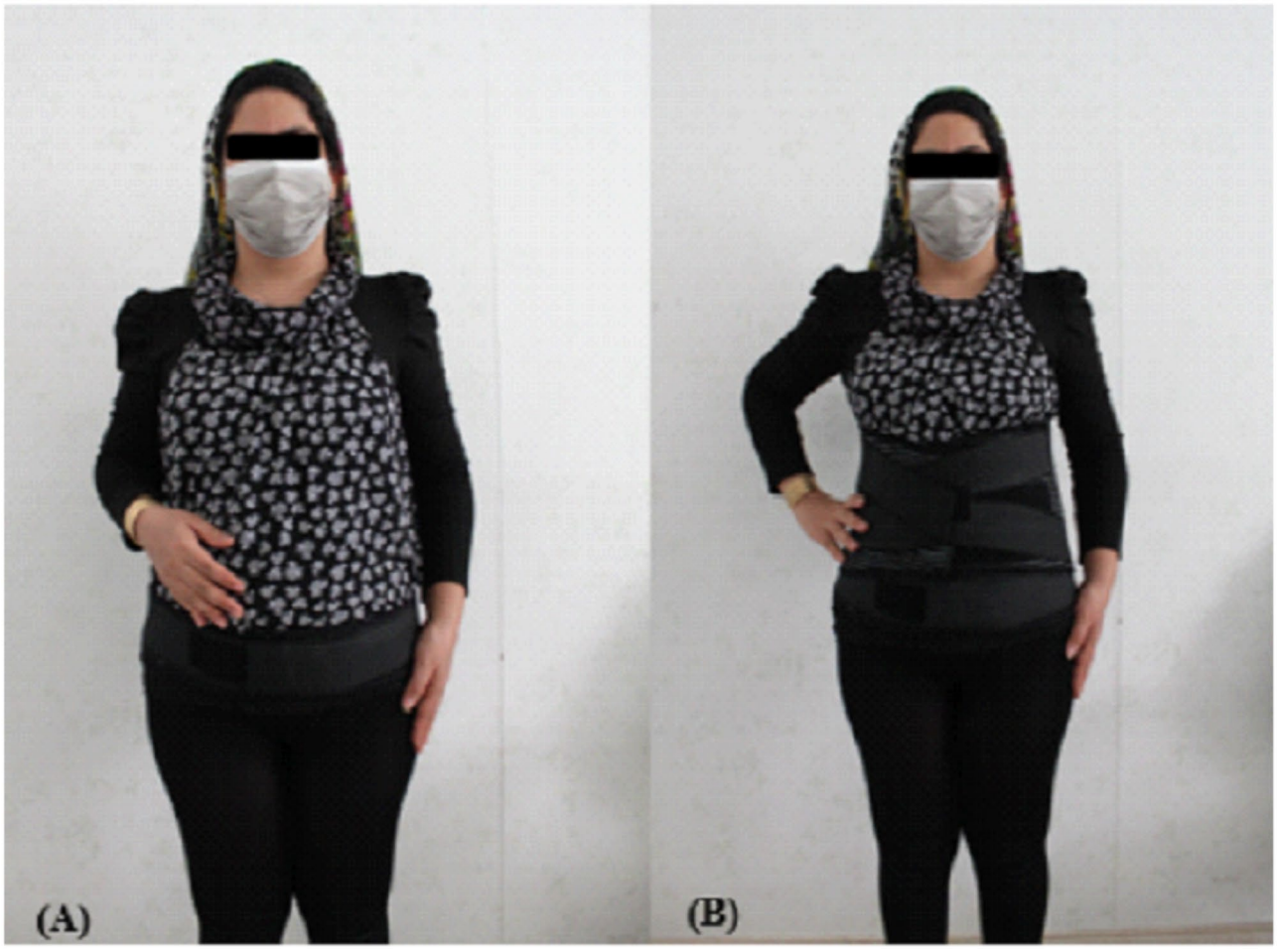


**Fig. 1** Study interventions: (**A**) pelvic support and (**B**) lumbar support

lasting effects of wearing support. The study flowchart is depicted in Fig. 2.

### Outcomes

The pain severity (as the primary outcome) was assessed using a 100 mm VAS four times (from baseline to 5-week follow-up). The disability score was measured by the Persian version of the Oswestry Disability Index (ODI) at baseline, after 4-week and 5-week follow-ups [27]. We prespecified several other outcomes, including effort during ASLR, maximum isometric muscle force (hip flexion and trunk rotation force), and joint position reproduction (JPR) of hip abduction.

The effort score during ASLR was measured while the participant lying in the supine position. We asked her to raise her involved leg to the target position (20 cm above the examination table). Her perceived effort difficulty was indicated on a 6-point Likert scale ranging from 0 to 5, where 0 = no problem and 5 = unable to do [28].

To measure maximum isometric hip flexion force, a digital force gauge was attached to the metal bar and adjusted to be placed immediately above the ankle. The participant was asked to raise her involved leg and compress the force gauge probe [29]. The test was repeated 3 times at a 20-second interval. The mean value was reported (Fig. 3-A).

To measure the maximum isometric trunk rotation force, the participant sat on the chair with her feet resting on the floor. The force gauge was fixed between the sub-clavicular area and the chest diagonal strap at one side. The participant was asked to rotate her trunk toward the opposite side and exert isometric force on the force probe. The test was repeated 3 times at a 20-second interval. The mean value was reported. The test was performed on the opposite side using the same procedure [30] (Fig. 3-B).

To measure maximum isometric hip external rotation force, she was asked to sit upright on the chair with her hip and knee positioned in approximately 90° flexion. A force gauge was secured between the medial side of her involved leg and the stabilization strap. She was instructed to pull her leg inward with maximal effort. The test was repeated 3 times at a 20-second interval. The mean value was reported [31] (Fig. 3-C).

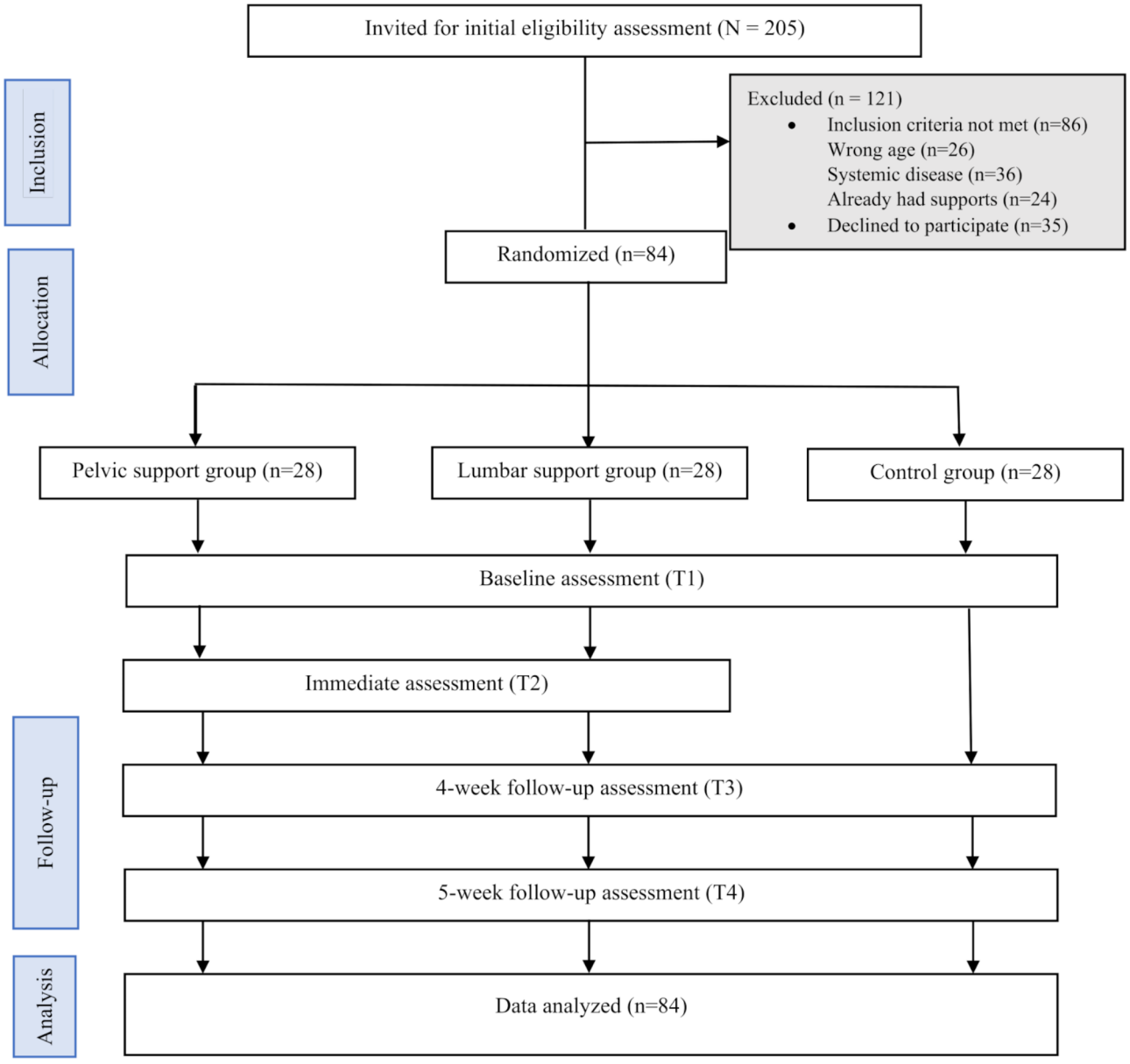


**Fig. 2** Trial profile for screening, randomization, and disposition of participants

JPR of hip abduction was measured while the participant standing with closed eyes on the uninvolved leg on a 10-cm-high wooden block. During the trial, the examiner sat behind the participant and checked the reference position and target angle. The hip abduction angle was quantified using a large protractor attached in front of the participant on the wall. The participant randomly selected the target angle between 10° to 40° for 4 trials [32]. In the first trial, the examiner instructed the participant on the "STOP" command to inform her of reaching the target angle. The participant held her leg at the target angle for approximately 4 s to memorize it. Then, the examiner asked the participant to return her leg to a reference position of 0° by saying "Return" and holding the leg there for 3 s. Next, the participant was asked to actively reproduce the previous target angle 3 times [32] (Fig. 3-D). The movement was recorded using a Canon camera (EOS-500D, DS126231) placed behind the participant at a distance of 2.5 m. The camera's tracking angles were analyzed using Kinovea software (Version 0.9.2). A previously published article reports a complete list of the outcomes and how to evaluate them [26].

### Other measures

To describe the study sample, we assessed various demographic and clinical variables, such as age, weight, height, body mass index (BMI), postpartum day, involved month in pregnancy, and duration of wearing support per day


**Fig. 3** Outcomes were measured in this study: Maximum isometric hip flexion force (**A**), Maximum isometric trunk rotation force (**B**), Maximum isometric hip external rotation force (**C**), Joint position reproduction of hip abduction (**D**)

(Participants were asked daily about the duration of support wear).

### Statistical analysis

The optimal sample size was established by considering a power of 0.6, which had a minimum acceptable value for clinical trials [31], an effect size of 0.44 (Cohen d) for pain reduction with pelvic support in the prior study, and an α level of 0.1 due to small group sizes [33]. These calculations were performed using G*power software (version 3.1, University of Düsseldorf) and detailed in a published study protocol [26]. To consider an overall dropout rate of 10% (e.g., lost to follow-up), a sample size of 28 was required in each of the three study arms. All analyses were carried out using the Statistical Package for the Social Sciences (SPSS, Version 25). Analyses were conducted on an intention-to-treat basis, handling missing data.

Repeated-measures MANOVA was performed to assess the hypothesized changes in variables from baseline to the end of the study. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity regression, multicollinearity and singularity, and homogeneity of variance-covariance matrices.

In this model, the interaction effects of group × time for the three groups and the various assessment times for the outcomes were particularly interesting. Whenever significant interaction effects were found, univariate post hoc tests with repeated measures were conducted to examine further interaction effects for the corresponding outcome between the groups and between the assessment times.

As the other outcomes were used in a confirmatory analysis and to control for type I error, alpha-Bonferroni adjustment was used for the post hoc between-group comparisons. Our study had six dependent variables to investigate; therefore, we divided 0.05 by 6, giving a new adjusted alpha level of 0.008. We considered our results significant only if the *p* values (sig.) were less than 0.008. In repeated-measures MANOVAs, eta squared values of 0.01–0.06 indicate a small effect, 0.06–0.14 a medium effect, and values above 0.14 a large effect of time×group [33]. In the post hoc between-group comparisons, the Cohen d values less than 0.2 indicate a small effect, 0.5–0.8 a medium effect, and values above 0.8 a large effect [33].

## Results

Eighty-four participants were eligible and completed their assigned trial with no early departures. The participants' demographic and clinical characteristics are summarized in Table 1, with no statistical differences among the groups at baseline. The interventions caused no serious adverse effects or injuries. All 84 participants completed all testing sessions.

### Efficacy of interventions

Repeated-measures MANOVA revealed a significant interaction effect for group × time on pain: $F_{3, 80} = 23.95$, $p < 0.001$; Wilks' Lambda = 0.27; partial eta squared = 0.47; disability score: $F_{2, 81} = 19.18$, $p < 0.001$; Wilks' Lambda = 0.45; partial eta squared = 0.32. Table 2 shows the means and standard deviations of the outcomes and summarizes the results of the repeated-measures MANOVA of the group × time effects for each comparison between different time points. This analysis demonstrated significant group × time effects for all dependent variables ($p < 0.001$) except for the JPR of hip abduction ($P = 0.13$).

**Table 1** The participants' demographic and clinical characteristics

| Variables | Pelvic support group M ± SD (*n* = 28) | Lumbar support group M ± SD (*n* = 28) | Control group M ± SD (*n* = 28) | Total M ± SD (Min-Max) (*n* = 84) |
|---|---|---|---|---|
| **Age (year)** | 30.6 ± 4 | 30.3 ± 4.6 | 30.6 ± 5.3 | 30.5 ± 4.6 (18–41) |
| **Weight (Kg)** | 70.22 ± 12.8 | 68.7 ± 11 | 73.8 ± 12.2 | 70.9 ± 12.1 (46.5–116) |
| **Height (cm)** | 163.7 ± 6 | 162 ± 6 | 164.2 ± 5 | 163 ± 5 (146–175) |
| **Body Mass Index (Kg/m$^2$)** | 25.84 ± 4.1 | 25.72 ± 3.6 | 27.1 ± 4.9 | 26.6 ± 4.3 (18.2–44.2) |
| **Postpartum time (day)** | 43.1 ± 7.4 | 47.5 ± 8.2 | 43.5 ± 8.1 | 44.7 ± 8.1 (31–59) |
| **Involved month in pregnancy (month)** | 4.7 ± 1.7 | 4.8 ± 2.1 | 4.4 ± 2.1 | 4.6 ± 2 (1–9) |
| **Duration of the wearing support per day (hour)** | 7 ± 2.8 | 5.8 ± 2.1 | --- | 6.4 ± 2.6 (4–12) |

**Table 2** Means and standard deviations for all variables per group for study time-points and results of repeated-measures MANOVA

| Variable | Conditions | Time-points | | | | Repeated-measures MANOVA |
|---|---|---|---|---|---|---|
| | | T1 (M ± SD) | T2 (M ± SD) | T3 (M ± SD) | T4 (M ± SD) | |
| **Pain** | Pelvic support | 6.2 ± 0.95 | 5.07 ± 1.01 | 3.6 ± 1.3 | 3.9 ± 2 | Wilk's Lambda = 0.27, F(3,80) = 23.95, $p < 0.001^*$, ŋ2 = 0.47 |
| | Lumbar support | 5.7 ± 0.96 | 4.42 ± 0.1 | 2.5 ± 0.92 | 1.8 ± 1.2 | |
| | Control | 5.6 ± 0.82 | 5.6 ± 0.82 | 5.6 ± 0.72 | 5.7 ± 0.7 | |
| **Disability score** | Pelvic support | 47.7 ± 14.8 | ----- | 32.6 ± 21.2 | 36.5 ± 27 | Wilk's Lambda = 0.45, F(2,81) = 19.18, $p < 0.001^*$, ŋ2 = 0.32 |
| | Lumbar support | 45.7 ± 13.5 | ----- | 20.7 ± 8 | 16.9 ± 11.5 | |
| | Control | 44.7 ± 13.1 | ----- | 53 ± 13.2 | 55.8 ± 12 | |
| **Effort during ASLR** | Pelvic support | 4.5 ± 0.7 | 3.14 ± 0.8 | 1.8 ± 1.2 | 2.2 ± 1.8 | Wilk's Lambda = 0.23, F(3,80) = 28.68, $p < 0.001^*$, ŋ2 = 0.52 |
| | Lumbar support | 4.2 ± 0.9 | 2.92 ± 0.7 | 1.2 ± 0.7 | 0.6 ± 0.9 | |
| | Control | 3.7 ± 0.9 | 3.7 ± 0.9 | 3.6 ± 0.6 | 3.8 ± 0.8 | |
| **Hip flexion force (N)** | Pelvic support | 53.2 ± 18 | 63.3 ± 18.8 | 67.7 ± 19.4 | 63.1 ± 20.4 | Wilk's Lambda = 0.46, F(3,80) = 12.58, $p < 0.001^*$, ŋ2 = 0.32 |
| | Lumbar support | 48.5 ± 16.4 | 62.6 ± 18.8 | 68.1 ± 18.4 | 67.5 ± 18 | |
| | Control | 30.4 ± 12.4 | 30.4 ± 12.4 | 28.4 ± 12.7 | 27.3 ± 11.9 | |
| **Trunk rotation force(N)** | Pelvic support | 41.4 ± 10 | 40.4 ± 9.4 | 40.6 ± 9.9 | 38.6 ± 9.9 | Wilk's Lambda = 0.25, F(3,80) = 25.75, $p < 0.001^*$, ŋ2 = 0.49 |
| | Lumbar support | 37.8 ± 12.1 | 45.7 ± 11.6 | 50.7 ± 11.7 | 52.5 ± 12.2 | |
| | Control | 29.2 ± 5.7 | 29.2 ± 5.7 | 27.1 ± 5.6 | 26.1 ± 4.9 | |
| **JPR of hip abduction (d)** | Pelvic support | 3.1 ± 2.4 | 2.76 ± 2.4 | 2.9 ± 2 | 2.5 ± 2.8 | Wilk's Lambda = 0.88, F(3,80) = 1.67, $p = 0.13$, ŋ2 = 0.06 |
| | Lumbar support | 2.3 ± 2.1 | 2.8 ± 1.8 | 3.5 ± 2.7 | 3.6 ± 3.1 | |
| | Control | 3.5 ± 2 | 3.5 ± 2 | 3.4 ± 2.2 | 2.9 ± 2 | |

MANOVA: multivariate analysis of variance; N: newton; d: degree; ŋ2: partial eta squared; M ± SD: mean ± standard deviation. *Indicates a statistically significant difference between groups ($p < 0.05$)

### Outcomes

The results of pairwise comparisons at different study time points for each outcome are summarized in Table 3. Additionally, the changes in the means within groups from baseline to 5-week follow-up for all outcomes are presented in Fig. 4.

The repeated-measures MANOVA results showed that the only significant difference in pain intensity immediately after the intervention, as measured with the VAS, was ascribed to the lumbar support vs. the control ($p < 0.001$). There were statistically significant reductions in pain intensity in all three conditions after 4-week and 5-week follow-ups ($p < 0.001$). According to Cohen's d, which ranged from 0.97 to 3.97, these effects were large. Within-group comparisons revealed a continued decrease in pain intensity during the follow-up period in the lumbar support group. However, it remained unchanged from the 4-week to 5-week follow-up in the pelvic support group. Pain intensity remained relatively stable during the study time points in the control group (Fig. 4A).

Results of disability score, as measured with the ODI, demonstrated that there was a statistically significant difference after a 4-week follow-up (pelvic support vs. control and lumbar support vs. control) ($p < 0.001$). There were statistically significant reductions in disability scores in all three conditions after 5-week follow-up ($p < 0.001$). These effects were relatively large based on Cohen's d, which varied from 0.74 to 3.3. The findings of within-group comparisons showed a growth trend from baseline to 5-week follow-up in the control group. However, there was a decreasing slope in disability scores in the lumbar support from baseline to 5-week follow-up. The pelvic support scores decreased after a 4-week follow-up and then increased after a 5-week follow-up (Fig. 4B).

There were significant differences in the mean change in effort during ASLR, as measured with the Likert scale immediately after the intervention (lumbar support vs. control), after 4-week follow-up (lumbar and pelvic supports vs. control), and all conditions after 5-week follow-up ($P < 0.008$). Per the Cohen's d values, which varied from 0.61 to 3.75, these effects were medium to large. The findings of within-group comparisons showed that effort scores during ASLR reduced until the 4-week follow-up in the participants who used lumbar and pelvic support. However, the lumbar support group exhibited greater improvement in effort during ASLR after a 5-week follow-up (Fig. 4C).

Differences between lumbar and pelvic supports vs. control groups were significant in the mean change in hip flexion force, as measured with a digital force gauge just after the intervention, after 4-week and 5-week follow-ups ($P < 0.001$). The effect sizes were large (cohen d values ranged from 1.24 to 2.63). Within-group comparisons revealed that hip flexion force in the control group remained unchanged from baseline to 5-week follow-up. However, the two intervention groups did not differ from one another and behaved similarly to each other from baseline to 5-week follow-up. Both interventions showed

**Table 3** The results of pairwise comparisons at different study time-points for each outcome and repeated measures of ANOVA

| Variable | Time-points | Conditions | MD ± SE (95%CI) | *P* value (Cohen d) |
|---|---|---|---|---|
| **Pain** | T1 | PS vs. LS | 0.46 ± 0.24 (-1.36 to 1.06) | 0.18 (0.52) |
| | | PS vs. Control | 0.57 ± 0.24 (-0.02 to 1.17) | 0.06 (0.67) |
| | | LS vs. Control | 0.1 ± 0.24 (-0.49 to 0.7) | 1 (0.11) |
| | T2 | PS vs. LS | 0.64 ± 0.25 (0.02 to 1.26) | 0.04 (0.9) |
| | | PS vs. Control | -0.57 ± 0.25 (-1.19 to 0.04) | 0.08 (0.57) |
| | | LS vs. Control | -1.21 ± 0.25 (-1.83 to -0.59) | < 0.001* (2.02) |
| | T3 | PS vs. LS | 1.07 ± 0.28 (0.38 to 1.75) | 0.001* (0.97) |
| | | PS vs. Control | -2.03 ± 0.28 (-2.72 to -1.34) | < 0.001* (1.9) |
| | | LS vs. Control | -3.1 ± 0.28 (-3.79 to -2.42) | < 0.001* (3.75) |
| | T4 | PS vs. LS | 2.1 ± 0.38 (1.17 to 3.04) | < 0.001* (1.27) |
| | | PS vs. Control | -1.75 ± 0.38 (-2.68 to -0.81) | < 0.001* (1.2) |
| | | LS vs. Control | -3.85 ± 0.38 (-4.79 to -2.92) | < 0.001* (3.97) |
| **Disability score** | T1 | PS vs. LS | 2 ± 3.7 (-7.05 to 11.05) | 1 (0.14) |
| | | PS vs. Control | 3 ± 3.7 (-6.05 to 12.05) | 1 (0.21) |
| | | LS vs. Control | 1 ± 3.7 (-8.05 to 10.05) | 1 (0.07) |
| | T2 | ---------- | ---------- | ---------- |
| | T3 | PS vs. LS | 11.85 ± 4.04 (1.96 to 21.74) | 0.01 (0.74) |
| | | PS vs. Control | -20.35 ± 4.04 (-30.24 to -10.46) | < 0.001* (1.15) |
| | | LS vs. Control | -32.21 ± 4.04 (-42.1 to -22.32) | < 0.001* (2.95) |
| | T4 | PS vs. LS | 19.64 ± 4.89 (7.66 to 31.61) | < 0.001* (0.94) |
| | | PS vs. Control | -19.28 ± 4.89 (-31.26 to -7.31) | 0.001* (0.92) |
| | | LS vs. Control | -38.92 ± 4.89 (-50.9 to -26.95) | < 0.001* (3.3) |

**Table 3** (continued)

| Variable | Time-points | Conditions | MD ± SE (95%CI) | *P* value (Cohen d) |
|---|---|---|---|---|
| **Effort during ASLR** | T1 | PS vs. LS | 0.21 ± 0.22 (-0.34 to 0.76) | 1 (0.37) |
| | | PS vs. Control | 0.78 ± 0.22 (0.23 to 1.34) | 0.003* (0.99) |
| | | LS vs. Control | 0.57 ± 0.22 (0.01 to 1.12) | 0.04 (0.55) |
| | T2 | PS vs. LS | 0.21 ± 0.21 (-0.31 to 0.74) | 0.97 (0.29) |
| | | PS vs. Control | -0.53 ± 0.21 (-1.06 to -0.005) | 0.04 (0.65) |
| | | LS vs. Control | -0.75 ± 0.21 (-1.28 to -0.22) | 0.003* (0.96) |
| | T3 | PS vs. LS | 0.64 ± 0.23 (0.06 to 1.21) | 0.02 (0.61) |
| | | PS vs. Control | -1.75 ± 0.23 (-2.32 to -1.17) | < 0.001* (1.89) |
| | | LS vs. Control | -2.39 ± 0.23 (-2.96 to -1.81) | < 0.001* (3.68) |
| | T4 | PS vs. LS | 1.53 ± 0.32 (0.73 to 2.33) | < 0.001* (1.12) |
| | | PS vs. Control | -1.6 ± 0.32 (-2.4 to -0.8) | < 0.001* (1.14) |
| | | LS vs. Control | -3.14 ± 0.32 (-3.94 to -2.34) | < 0.001* (3.75) |
| **Hip flexion force** | T1 | PS vs. LS | 4.76 ± 4.2 (-5.5 to 15.05) | 0.78 (0.27) |
| | | PS vs. Control | 22.87 ± 4.2 (12.58 to 33.15) | < 0.001* (1.47) |
| | | LS vs. Control | 18.1 ± 4.2 (7.81 to 28.38) | < 0.001* (1.24) |
| | T2 | PS vs. LS | 0.72 ± 4.53 (-10.36 to 11.8) | 1 (0.03) |
| | | PS vs. Control | 32.99 ± 4.53 (21.91 to 44.07) | < 0.001* (2.06) |
| | | LS vs. Control | 32.27 ± 4.53 (21.18 to 43.35) | < 0.001* (2.02) |
| | T3 | PS vs. LS | -0.42 ± 4.56 (-11.58 to 10.74) | 1 (0.02) |
| | | PS vs. Control | 39.28 ± 4.56 (28.12 to 50.44) | < 0.001* (2.39) |
| | | LS vs. Control | 39.7 ± 4.56 (28.54 to 50.86) | < 0.001* (2.51) |
| | T4 | PS vs. LS | -4.45 ± 4.58 (-15.66 to 6.76) | 1 (0.22) |
| | | PS vs. Control | 35.82 ± 4.58 (24.61 to 47.03) | < 0.001* (2.14) |
| | | LS vs. Control | 40.27 ± 4.58 (29.06 to 51.48) | < 0.001* (2.63) |

**Table 3** (continued)

| Variable | Time-points | Conditions | MD ± SE (95%CI) | *P* value (Cohen d) |
|---|---|---|---|---|
| **Trunk rotation force** | T1 | PS vs. LS | 3.57 ± 2.58 (-2.74 to 9.88) | 0.51 (0.32) |
| | | PS vs. Control | 12.2 ± 2.58 (5.89 to 18.52) | < 0.001* (1.49) |
| | | LS vs. Control | 8.63 ± 2.58 (2.31 to 14.95) | 0.004* (0.9) |
| | T2 | PS vs. LS | -5.36 ± 2.47 (-11.42 to 0.69) | 0.1 (0.5) |
| | | PS vs. Control | 11.2 ± 2.47 (5.15 to 17.26) | < 0.001* (1.44) |
| | | LS vs. Control | 16.57 ± 2.47 (10.51 to 22.63) | < 0.001* (1.8) |
| | T3 | PS vs. LS | -10.04 ± 2.52 (-16.21 to -3.88) | < 0.001* (0.93) |
| | | PS vs. Control | 13.56 ± 2.52 (7.39 to 19.72) | < 0.001* (1.67) |
| | | LS vs. Control | 23.6 ± 2.52 (17.44 to 29.77) | < 0.001* (2.57) |
| | T4 | PS vs. LS | -13.91 ± 2.54 (-20.14 to -7.69) | < 0.001* (1.25) |
| | | PS vs. Control | 12.49 ± 2.54 (6.27 to 18.72) | < 0.001* (1.6) |
| | | LS vs. Control | 26.41 ± 2.54 (20.19 to 32.63) | < 0.001* (2.83) |
| **JPR of hip abduction** | T1 | PS vs. LS | 086 ± 0.58 (-0.56 to 2.3) | 0.42 (0.35) |
| | | PS vs. Control | -0.34 ± 0.58 (-1.77 to 1.08) | 1 (0.18) |
| | | LS vs. Control | -1.21 ± 0.58 (-2.64 to 0.21) | 0.12 (0.58) |
| | T2 | PS vs. LS | -0.04 ± 0.56 (-1.41 to 1.32) | 1 (0.01) |
| | | PS vs. Control | -0.7 ± 0.56 (-2.07 to 0.66) | 0.64 (0.33) |
| | | LS vs. Control | -0.65 ± 0.56 (-2.02 to 0.71) | 0.73 (0.36) |
| | T3 | PS vs. LS | -0.53 ± 0.61 (-2.05 to 0.97) | 1 (0.25) |
| | | PS vs. Control | -0.42 ± 0.61 (-1.94 to 1.08) | 1 (0.23) |
| | | LS vs. Control | 0.1 ± 0.61 (-1.4 to 1.62) | 1 (0.04) |
| | T4 | PS vs. LS | -1.09 ± 0.72 (-2.86 to 0.66) | 0.39 (0.37) |
| | | PS vs. Control | -0.4 ± 0.72 (-2.16 to 1.36) | 1 (0.16) |
| | | LS vs. Control | 0.69 ± 0.72 (-1.07 to 2.45) | 1 (0.26) |

MD: mean difference; SE: standard error; JPR: joint position reproduction; T1: baseline; T2: immediate effect; T3: 4-week follow-up; T4: 5-week follow-up (wash-out period); CI: confidence interval; PS: pelvic support; LS: lumbar support. * Indicates a statistically significant difference between groups ($p < 0.008$)

hip flexion force enhancement until the 4-week follow-up and reduction after the 5-week follow-up (Fig. 4D).

The results of repeated-measures MANOVA showed significant differences in the mean change in trunk rotation force, as measured with a digital force gauge immediately after the intervention (lumbar and pelvic supports vs. control) and all three conditions after 4-week and 5-week follow-ups ($P < 0.001$). Based on Cohen's d, which ranged from 0.9 to 2.83, the effect sizes were large. Within-group comparisons revealed that trunk rotation

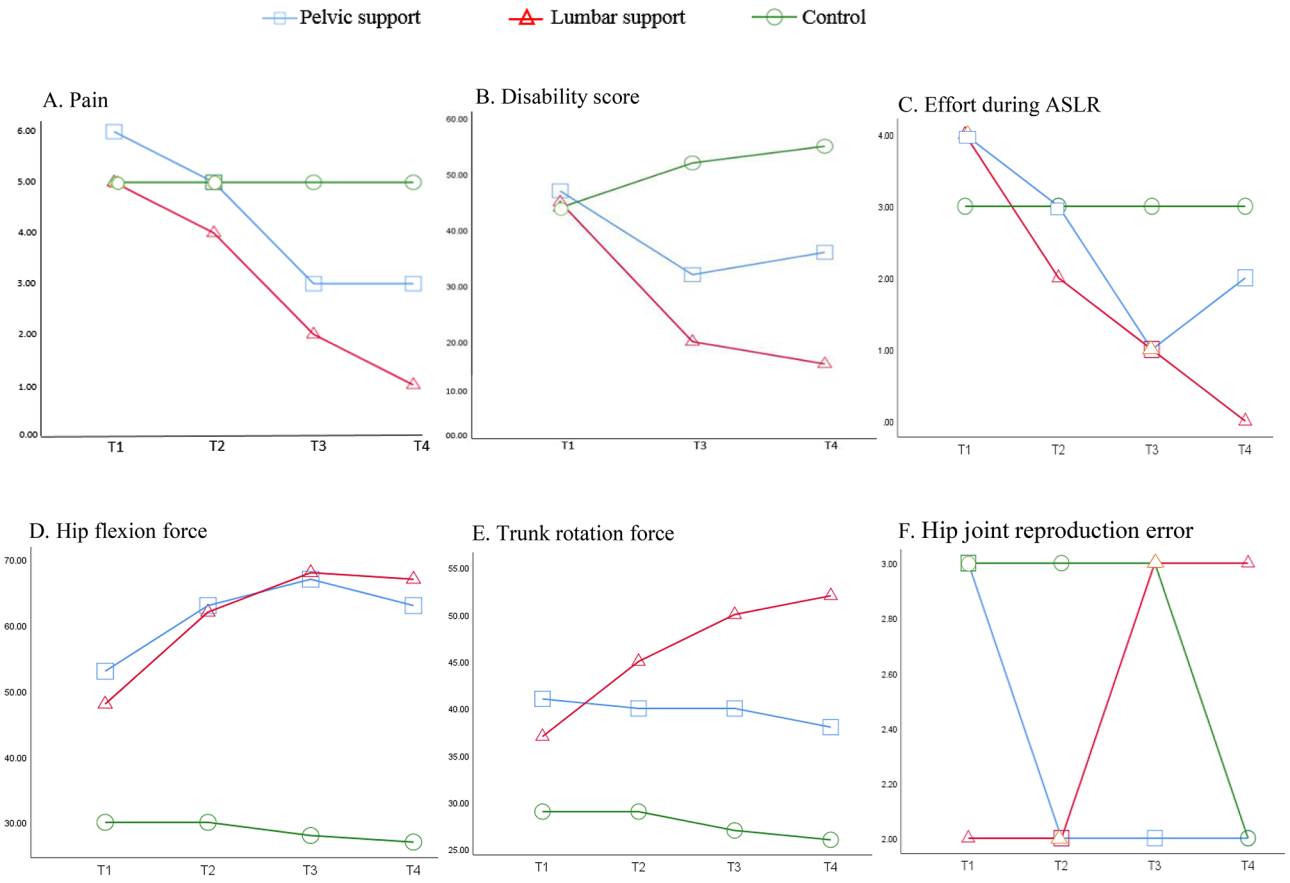


**Fig. 4** The changes in mean within-group from baseline to each assessment point. **A** to **F**: primary and secondary outcomes. T1:baseline; T2:immediate effect; T3: 4-week follow-up; T4: 5-week follow-up (wash-out period)

force slowly decreased from baseline to 5-week follow-up in the control and pelvic support groups. However, the lumbar support significantly improved more than the other groups from immediately after the intervention to a 5-week follow-up (Fig. 4E).

The results revealed no significant differences in the JPR of hip abduction at any of the study time points between and within groups ($P > 0.008$).

## Discussion

The efficacy of Lumbar support on pain, disability, and motor control in women with postpartum PPGP is being investigated for the first time in this RCT. The study demonstrated that lumbar and pelvic supports can be beneficial for women with PPGP. Lumbar support was more effective than pelvic support in improving disability, effort in ASLR, pain intensity, and trunk rotation strength.

Our results showed that participants in the lumbar (Cohen d = 3.97) and pelvic support (Cohen d = 1.2) groups reported significantly less pain intensity after the 4-week follow-up than women in the control group. These results align with the findings of Patil's [13] and Mens et al.'s [19] studies that reported women with PPGP could benefit from supportive pelvic belts to reduce pain in the postpartum period. Clinically significant results from our study found that lumbar support more effectively reduced pain intensity than pelvic support in women with PPGP. Our results showed that the lumbar support group experienced more pain relief than the pelvic support group after 4-week and 5-week follow-ups (Cohen d = 0.14). The small effect size in comparing pelvic and lumbar support suggests that women with PPGP may benefit from either option for pain relief. Using lumbar support may have a little advantage due to stimulation of skin receptors or compression of the soft tissues around the spine and pelvic joint receptors compared to pelvic support [34]. Furthermore, it is possible that lumbar support has biomechanical effects on the lumbar area and reduces mechanical loading to the trunk muscles in daily living [35] more effectively than pelvic support.

Previous research has demonstrated that lumbopelvic supports that cover a larger region may provide more pain alleviation [13, 35], which is consistent with our findings. The current study, in our opinion, somewhat addresses the shortcomings of earlier research. Due to

the absence of a comparative efficacy with the control group (no orthosis or placebo) [13] and another study investigating the effect of lumbopelvic support on a small number of participants ($n = 16$, with 8 women in each group) that may restrict the generalizability of their findings [13].

PPGP impacts the ability of women to perform activities of daily living (ADLs) and their quality of life [36]. Considering disability score measurements in the PPGP, only one study has directly compared the efficacy of a belt intervention in the postpartum PPGP [13]. Patil et al. suggested that existing belts could provide more efficient support for the abdomen and pelvic areas if some modifications were made to their structures. In this case, the participants involved have minimal or no discomfort performing their daily activities [13]. The findings showed that the lumbar (Cohen d = 3.3) and pelvic support (Cohen d = 0.94) groups had lower disability scores than the control group after four weeks. Lumbar support showed a significantly more clinically meaningful improvement in enhancing ADL compared to pelvic support. This result has important clinical implications for improving decision-making regarding the treatment of women with PPGP. However, a more remarkable improvement was observed in the lumbar support than in the pelvic support group (Cohen d = 0.92) after the 4-week intervention. This finding may have clinical relevance since it suggests that participants may feel the lumbar is more comfortable when performing ADLs using broader support.

The Effort score during ASLR has been used as a clinical parameter for the diagnosis and severity of PPGP [37]. The study's results showed that the effort score during ASLR improved when both lumbar (Cohen d = 3.75) and pelvic (Cohen d = 1.14) supports were used for the 4-week intervention period. There was a greater reduction in the effort score during ASLR with lumbar support than with pelvic support (Cohen d = 1.12). A clinically significant difference between groups showed that the participant could perform the ASLR with less effort while wearing the lumbar support. This suggests that lumbar support may offer greater joint stability than pelvic support during hip flexion. It is generally believed that pregnancy is associated with pelvic misalignment and instability, which can be alleviated by using a belt [38]. Based on these results, lumbar support could stabilize the lumbar and pelvic joints more effectively than pelvic support. The lumbar support also improves muscle function for load transfer over the pelvic region, providing more stabilization than the pelvic support [39].

The results showed that lumbar and pelvic supports increased the maximum isometric hip flexion force immediately after the intervention and after the 4-week follow-up. However, women in the control group exhibited limited hip flexion force. An explanation could be that involved women try to stabilize the pelvis with more muscle activity but cannot produce adequate muscle force to raise their legs [29]. A previous study showed that using a pelvic belt positively impacted the ASLR and patients were able to raise their legs with no effort [8]. The lumbar and pelvic supports might increase pelvic joint stiffness, which requires unloading sensitized ligamentous structures. This stiffness improvement could produce more normalized motor responses during the hip flexion test [29]. Clinically, both supports may enhance hip flexion force similarly, but lumbar support outperformed pelvic support in this test.

The lumbar support improved trunk rotation muscle force during the intervention and follow-up periods (Cohen d = 2.83), and pelvic support had less effect on trunk rotation muscle force (Cohen d = 1.6) after four weeks. The results indicated a significant difference in trunk rotation muscle force between the groups, suggesting that lumbar support may be a more effective option for clinicians to improve trunk rotation muscle strength in women with PPGP. The following explanations for how the lumbar support could manage trunk movements have been proposed: improving proprioception, enhancing force closure muscle activity, and stiffening the trunk. The enhanced proprioception may stem from increased stimulation of cutaneous mechanoreceptors [16]. Aside from providing additional proprioceptive input, it has been suggested that lumbar support may also help regulate trunk movements and optimize lumbopelvic stabilization for normal load transference through the pelvis [40]. Some authors suggest that lumbar supports increase trunk stiffness by making the entire spinal column more robust to perturbation [41]. Indeed, participants perceived added support just after wearing lumbar support and increased confidence in undertaking trunk movements [42].

The effect of orthotic interventions on proprioception in the PPGP has not been studied. In this study, proprioception was assessed by measuring the JPR of the hip joint in the standing position. This variable proved to be more accurate and reliable in the abduction movement of the hip joint than in the other movements [32]. Our findings revealed no clinically significant differences in the reproduction of hip joint abduction between the groups after the intervention or during the follow-up period. JPR measurement in a standing position on the symptomatic side might lead to asymmetrical shear loading through the SIJ, making it unstable during load transfer and aggravating the symptoms of PPGP [43]. Further research with different test positions or continuous use of supports for longer than a certain period might affect the JPR of the hip joint.

Pain and proprioception share neural pathways in the central nervous system, and pain signals can disrupt proprioceptive inputs, reducing accuracy in joint position sense and movement awareness [33]. Because women with greater pain scores were chosen for the study based on inclusion criteria, therefore the discussion should take into account the confounding effect of pain severity on the proprioception test. Perceived pain may lead to poor performance on proprioceptive assessments, not necessarily due to deficits in proprioception but rather as a result of pain-related mechanisms that inhibit regional movements. This adopted inhabitation strategy can hinder motor control and reduce the effectiveness of rehabilitation. Mal-adaptive changes in sensorimotor functions necessitate a structured sensory and motor training approach to restore normal motor function.

We observed large effect sizes for all outcomes (except JPR of hip abduction) for both lumbar and pelvic supports after the 4-week intervention (Cohen's $d > 0.8$). The clinical implications of the results suggest that the impact of both supports are clinically meaningful, although lumbar support showed a greater effect size than pelvic support. This trial demonstrated that lumbar support significantly alleviates pain, reduces disability, enhances effort during ASLR, and improves strength in trunk rotator and hip flexor muscles in women with pregnancy-related PPGP.

When treating lower back pain, it's usual practice to prescribe lumbar support in addition to exercise [39]. Lumbar supports offer external stability, particularly for those with weak core muscles or challenges in activating their stabilizing muscles. The risk of relying is reduced when lumbar support is used in conjunction with an exercise program. Combining lumbar support with exercise maximizes the advantages of both interventions, promoting a shift from extrinsic (orthosis-based) to intrinsic (muscle-based) lumbopelvic stability and functional outcomes over time.

We designed this trial with a wash-out period to explore each orthotic intervention's lasting effect (carry-over of effect). Participants discontinued using support after the 4-week follow-up, and variables were assessed one week later. In the lumbar support group, variable improvements continued even after removing the support. Upon removal of the pelvic support, the pain intensity remained unchanged. Moreover, disability, effort score during ASLR, and hip and trunk muscle force returned to their initial levels during the intervention. Therefore, a one-week wash-out phase might be more acceptable for future crossover studies using lumbar and pelvic supports.

The objective of the current study was to investigate the effectiveness of a single component of therapies for women with PPGP associated with pregnancy. Studies with PPGP rarely show consistent changes in motor control [44] and psychological factors could play a role in changing symptoms [45].

Some limitations were identified in this study, which could be used to improve the design of future large clinical trials. First, we examined trunk rotators for gross trunk movement and ignored specific muscles in detail. Second, the hip joint reproduction error variable did not significantly change when supports were used in the intervention groups. A larger sample size or longer intervention time is recommended for future studies. Third, the findings provide evidence only for the pregnancy-related PPGP population and cannot be easily generalized to individuals involved in SIJ pain. Fourth there was no placebo in this study, psychological effects or participant expectations-related effects of lumbar and pelvic support cannot be definitively determined.

Despite these limitations, our study provides practical knowledge for treatment planning and clinical decisions for women involved in pregnancy-related PPGP. Although pain tends to reduce even in the absence of intervention after a few months postpartum, the control group's pain and disability scores did not improve during the natural course of PPGP. However, it appears that in order to manage deteriorating symptoms, early intervention may be necessary for women who are involved.

## Conclusions

The findings of the present study suggest improvements in pain, disability, and stabilizing muscle strength after orthotic interventions in women with pregnancy-related PPGP. Lumbar support showed superior effects to pelvic support for symptom improvement. Future research should further assess the effectiveness of PPGP orthotic intervention along with sensory-motor training and the timing of the interventions.

### Abbreviations

| | |
|---|---|
| ADL | Activity daily living |
| ANOVA | Analysis of variance |
| ASLR | Active straight leg raise |
| IUMS | Isfahan university of medical sciences |
| JPR | Joint position reproduction |
| MANOVA | Multivariate analysis of variance |
| ODI | Oswestry disability index |
| PPGP | Posterior pelvic girdle pain |
| SIJ | Sacroiliac joint |
| VAS | Visual analogue scale |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12891-025-08350-3.

Supplementary Material 1

Supplementary Material 2

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**Author contributions**
FS-J, GY, and ES-D contributed substantially to the study design. FS-J recruited participants, managed the study process, and collected data under the supervision of MJ-H and ES-D. All authors reviewed, revised, and approved the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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**Data availability**
The datasets used and analysed during the current study are available from the corresponding author (E.S-D) at sadeghi@rehab.mui.ac.ir. upon reasonable request.

## Declarations

**Ethics approval and consent to participate**
This work was a research project approved by the Isfahan University of Medical Sciences Ethics Committee (Registration No: IR.MUI.NUREMA.REC.1400.007). Informed consent was obtained from all participants.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

**Author details**
[1]Musculoskeletal Research Center, School of Rehabilitation Sciences, Isfahan University of Medical Sciences, Hezar Jerib St, Isfahan, Iran
[2]Department of Obstetrics & Gynecology, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran
[3]Department of Health Professions, Manchester Metropolitan University, Manchester, UK

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