ORIGINAL RESEARCH ARTICLE

Plantar Pressure During Gait in Pregnancy-Related Pelvic Girdle Pain and the Influence of Pelvic Belts

Jeanne Bertuit, PhD, PT, Clara Leyh, MS, Veronique Feipel, PhD, PT

ABSTRACT

Introduction: Many pregnant women experience pelvic girdle pain (PGP) during pregnancy. Etiologies are multifactorial and affect the joint stability of the sacroiliac joint. Pelvic belts could restore stability and help reduce pain during gait. The objectives were to analyze plantar pressure during gait in pregnant women with PGP, to evaluate the effect of pelvic belts, and to compare the effects of two types of belts on plantar pressure parameters.

Materials and Methods: Forty-six pregnant women with PGP, 58 healthy pregnant women, and 23 nonpregnant women were recruited. The motor task consisted of three-gait trials on a walkway. Plantar pressure was analyzed with four variables. Two types of pelvic belts for pregnant women were used.

Results: Plantar pressure in women with PGP compared with controls showed differences in all parameters: they displayed lower gait velocity and lower values for most pressure variables at the rear and forefoot (medial side). Conversely, these values were higher for the midfoot (lateral side). These alterations were also found in healthy pregnant women. There was no difference in plantar pressure between groups, those who had or had not used belts, and between the types of belt.

Conclusions: Pregnant women, with or without PGP, showed nearly the same changes in plantar pressure during gait. PGP did not change plantar pressure parameters. Wearing any of the belts during pregnancy did not have an effect on plantar pressure parameters during gait in pregnant women with PGP. (*J Prosthet Orthot.* 2019;31:199–206)

KEY INDEXING TERMS: pregnant women, gait, pelvic girdle pain, belt, plantar pressure

Approximately 50% of pregnant women experience pelvic girdle pain (PGP).[1] PGP is reported as the most common cause of sick leave, with up to 32% of women having to take leave during pregnancy.[2] Pain is significant (60 ± 30 mm on visual analog scale [VAS]) and localized in the posterior region of the pelvis, between the posterior iliac crest and the gluteal fold, particularly in the vicinity of the sacroiliac joint (SIJ). It may include the symphysis pubic area.[3,4] Etiologies of PGP are multifactorial and affect the joint stability of the SIJ. The "self-locking" mechanism described by Vleeming in 1990[5] explains how shear in the SIJ is prevented by the combination of the anatomical features (form closure) and the compression generated by muscles and ligaments, which can be accommodated to the specific loading situation by a self-bracing mechanism (force closure). PGP seems to be related to hormonal and mechanical factors, which have an impact on force closure leading to instability by a slightly larger range of movement in the pelvic joints.[6,7] Women with PGP experience significant impairment during daily activities. Pain manifests mainly in the evening, indicating that pain starts or increases after activities. Standing or sitting, walking, and daily activities become limited.[3]

In the view of the mechanisms involved, muscle-strengthening exercises would seem a reasonable therapeutic approach. However, their efficacy was shown to be limited.[7,8] An alternative method suggested to restore pelvic stability is the use of a pelvic belt. It is hypothesized that a belt applied with even a small force should have the capacity to generate a "self-locking" mechanism.[9] Theoretically, the contention should press SIJ surfaces together and fix their position to provide SIJ stability by increasing the force closure, although this remains controversial.[10,11] A number of studies found that the use of pelvic belts decreased pain intensity by 20 mm (VAS) and made daily activities such as walking easier.[3,12]

Gait changes during pregnancy are made to obtain a safe gait, limiting the risk of falling.[13,14] For Bertuit et al.,[15] plantar pressure during gait in pregnant women is different from that of nonpregnant women. A decrease in peak pressure, contact area, and peak time was observed for the forefoot and rearfoot. In contrast, an increase in these parameters was observed for the midfoot. Studies[15,16] showed a lateralization of center of pressure during gait with an increase of the contact area in the lateral midfoot and both a reduced pressure and later peak time

JEANNE BERTUIT, PhD, PT, is affiliated with the School of Health Sciences (HESAV), University of Applied Sciences and Arts Western Switzerland (HES-SO), Lausanne, Switzerland.

JEANNE BERTUIT, PhD, PT; CLARA LEYH, MS; and VERONIQUE FEIPEL, PhD, PT, are affiliated with the Laboratory of Functional Anatomy, Faculty of Motor Sciences–Université Libre de Bruxelles (ULB), Brussels, Belgium.

CLARA LEYH, MS; and VERONIQUE FEIPEL, PhD, PT, are affiliated with the Laboratory of Anatomy, Biomechanics and Organogenesis, Faculty of Medicine–Université Libre de Bruxelles (ULB), Brussels, Belgium.

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Correspondence to: Jeanne Bertuit, PhD-PT, School of Health Sciences (HESAV), University of Applied Sciences and Arts Western Switzerland (HES-SO), Avenue de Beaumont 21, 1011 Lausanne, Switzerland; email: jeanne.bertuit@hesav.ch

in the medial forefoot, illustrating the modifications of gait in pregnant women. Consequently, pregnant women walk with foot pronation and increase the contact surface by 8% to 10%. These changes are linked to changes in the foot during pregnancy to uniformly distribute an increasing load without increasing the overall plantar pressure.[17,18] However, the results of other studies remain disparate.[16,17]

Studies have evaluated the relationship between foot position or movement and alignment of the lower limb.[19] Foot pronation is strongly coupled with internal rotation of the shank, both in walking and running. It has been suggested that abnormal movements and interaction between segmental alignments of the lower-limb increase risk of lower-limb injuries. Khamis and Yizhar[20] did not find a correlation between the change in foot hyperpronation and pelvic response and therefore concluded on a weak relationship between foot and pelvic alignment. On the contrary, for Khamis et al.,[19] an interaction exists between nearby segments as well as between distant segments such as the shank and pelvis. Thus, lower-limb and lower-back symptoms may require a comprehensive biomechanical evaluation of the foot and understanding of their interaction.

To date, only one study has evaluated biomechanical parameters during gait in pregnant women with PGP showing a potential influence of pain on gait.[21] No study has analyzed plantar pressure, although footprint modifications may contribute to the increased risk of musculoskeletal disorders in women.[18,22,23] Considering the limited amount of literature available on the subject, it is essential to improve our knowledge about plantar pressure changes during gait in pregnant women with PGP. If plantar pressure is different in pregnant women with pelvic pain, it would be interesting for clinical practice to be able to assess whether plantar pressure parameters could be modified with the use of a pelvic belt. Gait could be facilitated, making the belt a useful and valid tool for treatment and prevention. Belts are easy to use and without adverse effects, and could be well-suited for pregnant women with PGP.[14,24] However, there are many types of belts, which have not been assessed, making it difficult to use them as part of an evidence-based practice.

The first objective of this study was to analyze plantar pressure during gait in pregnant women with PGP. The second objective was to evaluate the effect of pelvic belts worn during 9 weeks of pregnancy on plantar pressure. The third objective was to compare two types of belts (narrow and flexible or broad and rigid).

METHODS

PARTICIPANTS

The characteristics of the three groups are presented in Table 1.

Recruitment was carried out at the Erasme University Hospital (Brussels, Belgium) in the gynecology-obstetrics and maternal care departments and during prenatal and postnatal gymnastics sessions. For the first group (PGP-PW), 66 pregnant women with PGP aged 25 to 35 years were recruited (Figure 1). The inclusion criteria were as follows: women from the 18th week of pregnancy, with pain in the SIJs and/or pubic region—as verified by a set of tests during clinical examination (posterior pelvic pain provocation test, Patrick Faber's test, Trendelenburg modified test, and active straight leg raise test).[24,25] The exclusion criteria were the presence of lumbopelvic pain before pregnancy, as well as other pathologies involving gait problems, surgery of the lumbar spine, pelvis, hips or knees, fractures, pain radiating below the knee, tumors or active inflammation in the lumbopelvic region, the presence of known anomalies of the spine, and rheumatic diseases. Twin pregnancies and pregnancies with complications were also exclusion criteria. Participants with PGP were randomized by throwing the dice into groups (A1/A2/B). Group A included 38 women who wore a belt during pregnancy but not during gait evaluation. Belts were used during 9 (±5) weeks of pregnancy. Seventeen women formed group A1 using belt 1 (22 women with 5 dropouts), and 21 women formed group A2 using belt 2 (24 women with 3 dropouts). Group B included 20 women who did not wear a belt. There were 12 dropouts, which reduced the number of women in this

Table 1. Characteristics of the study samples

Groups	Number	Age, y	Height, cm	Week of Pregnancy T1	Week of Pregnancy T2	Week of Pregnancy T1–T2	Mass Gain, kg
PGP-PW							
A							
A1	17	29 (5)	161 (4)	28 (4)	36 (1)	8 (4)	13 (5)
A2	21	30 (5)	162 (5)	26 (5)	35 (1)	9 (5)	12 (4)
A1 + A2	38	30 (5)	162 (5)	27 (5)	36 (2)	9 (5)	12 (5)
B	8	29 (5)	163 (6)	27 (6)	36 (2)	10 (7)	12 (2)
A + B	46	30 (5)	162 (5)	27 (5)	36 (2)	9 (5)	12 (4)
H-PW	58	29 (5)	166 (6)	33 (4)	/		10 (4)
CG	23	27 (5)	168 (6)	/	/		/

PGP-PW indicates pregnant women with pelvic girdle pain; H-PW, healthy pregnant women; CG, control group; A, women with belt during pregnancy (A1, women with belt 1, A2, women with belt 2); B, women without belt during pregnancy.

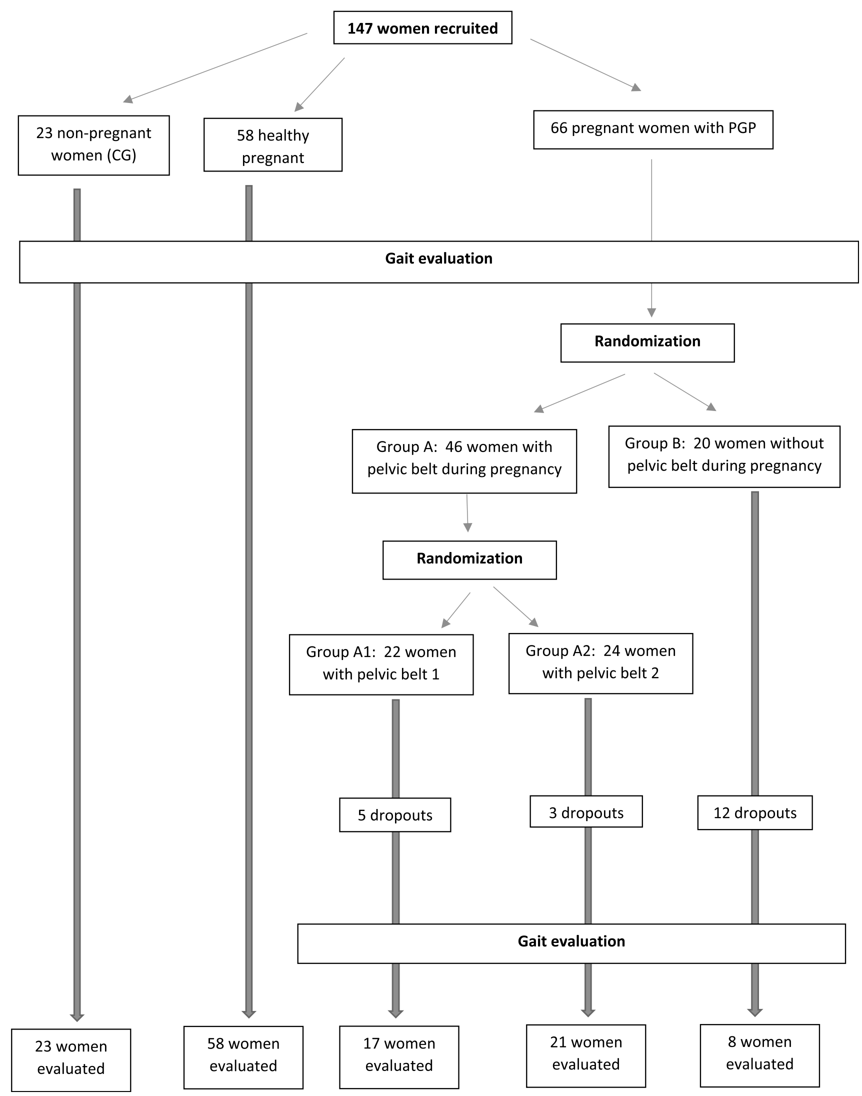

Figure 1. Flow diagram of participants.

group to 8. Thus 46 women with PGP completed the study. For the second group (H-PW), 58 healthy pregnant women aged between 24 and 31 years were included, from the 18th week of pregnancy (Figure 1). The exclusion criteria were the same as for PGP-PW, with the addition of the presence of lumbopelvic pain during pregnancy and pain in the SIJs and/or pubic area.

The third group, corresponding to the control group (CG), included 23 nonpregnant women of the same age range, free from pelvic pain, and without any previous surgery (Figure 1).

All subjects gave written informed consent before participation in the study, which was approved by the Ethics Committee of the University and Hospital Erasme (Brussels, Belgium; number P2011/017).

EQUIPMENT USED

Footprint parameters during gait were measured using the GAITRite electronic walkway (GAITRite Gold; CIR Systems, PA, USA; length, 6.1 m; width, 61 cm). Embedded pressure sensors form a horizontal grid. Data were sampled at a frequency of 100 Hz. The walkway is connected to a PC by a serial interface cable (GAITRite GOLD, version 3.9 software).

The GAITRite algorithm renders the footprint as a quadrangle, which is geometrically represented by 12 trapezoids: six medial

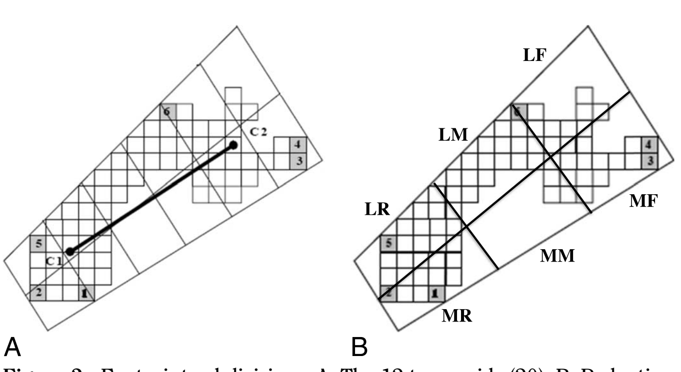

Figure 2. Footprint subdivisions. A, The 12 trapezoids (20). B, Reduction to 6 trapezoids. LR indicates lateral rearfoot; MR, medial rearfoot; LM, lateral midfoot; MM, medial midfoot; LF, lateral forefoot; MF, medial forefoot.

A B

Figure 3. Pelvic belts. (www.thuasne.com). A, belt 1; B, belt 2. © Thusasne, used with permission.

and six lateral (Figure 2A). To simplify the results, the 12 trapezoids were assembled two by two to obtain six zones corresponding to the following areas: medial and lateral rearfoot, medial and lateral midfoot, and medial and lateral forefoot (Figure 2B). The software provides a visual idea of pressure distribution with a chromatic pressure scale of seven levels. The system normalizes pressure value, and expresses it as a percentage of the maximum pressure.

Many types of pelvic supports are available and could be of use for pregnant women. They could have differential effects on pain during pregnancy.[3] Two pelvic belts for pregnant women were used:

- Belt 1 (Ortel-P, Thuasne; Figure 3A). This belt is narrow and flexible. The belt can be placed in two positions: high position (at the level of the anterior superior iliac spine) or low position (at the level of the pubic joint). Two belt positions are reported in the literature: a high position and a low position. Pelvic belt position is considered as having an impact on musculoskeletal structures and on stability. Belt application in a high position would mimic the action of multifidus and transverse abdominal muscles. Another study, suggesting the low position, observed an increased muscular activity in the pelvic floor.[10,26] Women first had the belt adjusted to their body and then modified the belt pressure themselves with the help of elastic Velcro systems on each side.
- Belt 2 (LombaMum, Thuasne; Figure 3B). This belt is broad and rigid with metal reinforcements in the lumbar area. It allows only one position, but a sophisticated Velcro system makes it possible to adjust tension to a number of different levels.

DATA COLLECTION

Each participant was invited to walk barefoot on the walkway. The motor task consisted of three-gait trials at the participant's preferred speed. A rest period was allowed if the participant felt tired. Its duration was not imposed (the maximum time used was 2 minutes). To counter the methodological bias of acceleration and deceleration in gait, participants started walking 2 m ahead of the walkway and finished the trial 2 m beyond the end of the walkway.

CG, H-PW, and PGP-PW performed a gait assessment without a belt (T1). The women in the PGP-PW group wore a belt for 9 (±5) weeks and were evaluated a second time without belt between the 34th and 38th week (T2).

DATA PROCESSING

Four dependent variables were analyzed for the six foot zones. P*t is the integrated pressure over time in a zone expressed as a percentage of the overall integrated pressure over time. Peak time is the first point in time at which one or more sensors in a zone were at the maximum level. Area represents the sum of the active sensor areas within a zone. Peak pressure is the maximum pressure per zone, expressed as a percentage of the overall maximum pressure per foot. The average values over all three trials were calculated.

STATISTICAL ANALYSIS

All of the statistical procedures were conducted using Statistica 5.0 software for Windows (StatSoft Inc, Tulsa, OK). To investigate the normal distribution of the data, we used the Kolmogorov-Smirnov test. All of the scores were found to be normally distributed. A Student's *t*-test for paired samples was

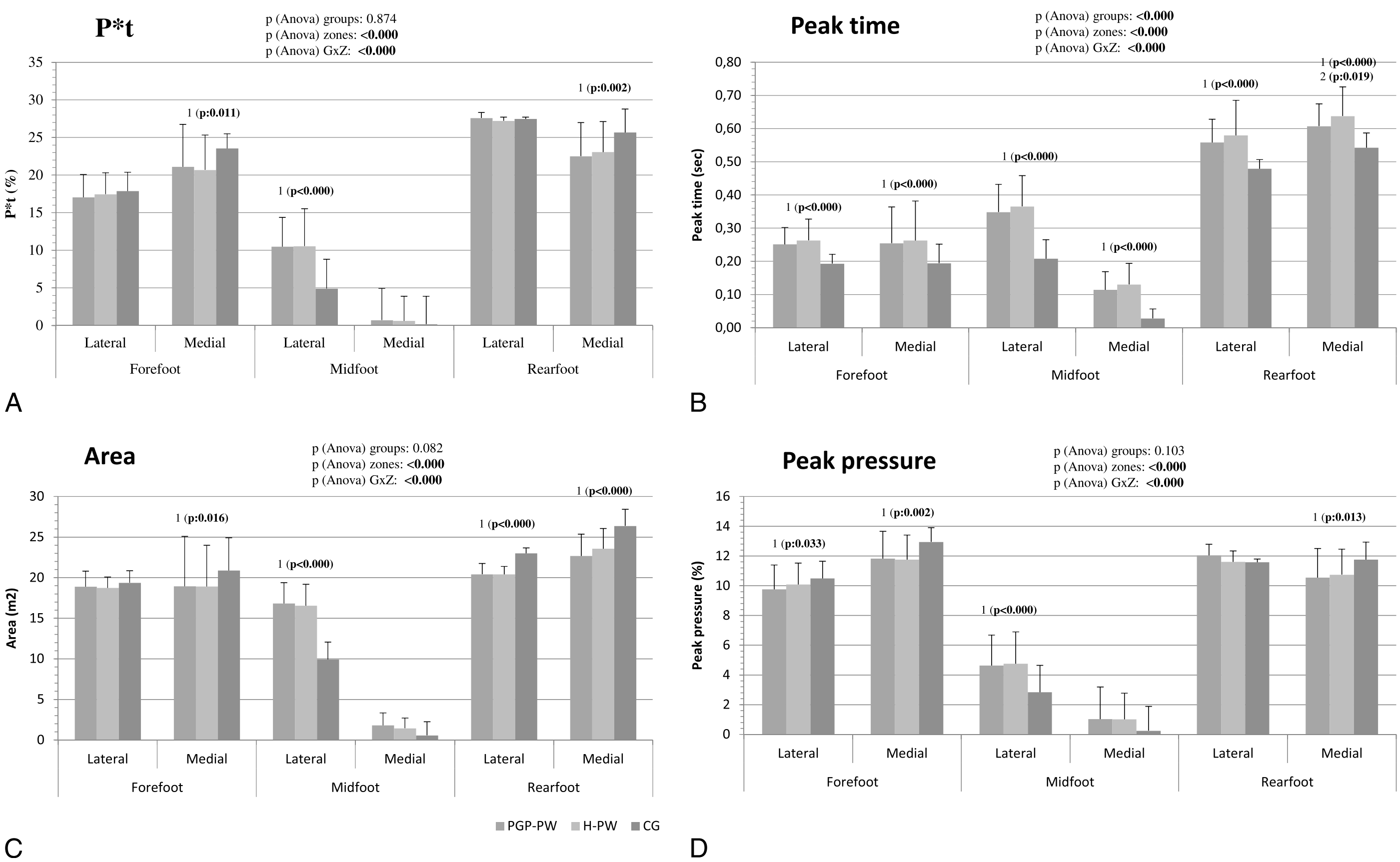

Figure 4. Mean ± SD value of the four footprint variables in the pregnant women with PGP (PGP-PW), healthy pregnant women (H-PW), and control group (CG) for the six zones. A, P*t. B, Peak time. C, Area. D, Peak pressure. Presented interaction groups × zones (GxZ). 1, PGP-PW/CG; 2, PGP-PW/H-PW.

not significantly different between sides; data from the left and right foot were, thus, averaged.

An analysis of variance (ANOVA) for repeated measures was performed for comparison of all dependent variables between the different foot zones and times (T1–T2; within subject factor) and groups (between groups factor). When a significant effect was found, the LSD post hoc test was applied. The statistical level of significance was set at 0.05.

RESULTS

No statistical differences were observed between groups for age, height, weeks of pregnancy, mass gain, and level of pain.

Gait velocity was slower by 19% to 20% in H-PW and PGP-PW as compared with CG ($P < 0.001$).

PLANTAR PRESSURE DURING GAIT

Figure 4 illustrates the results of the four parameters for the three groups (PGP-PW, H-PW, CG). The group effect was significant ($P < 0.001$) for peak time. The effect of zones was significant ($P < 0.001$) for the four parameters. This result led to analyzing the interactions between groups and zones (GxZ). The four parameters showed a significant interaction ($P < 0.001$). The comparison between PGP-PW and H-PW showed a 5% shorter peak time (medial rearfoot) for PGP-PW ($P = 0.019$). The comparison between PGP-PW and GC showed differences in all parameters. P*t was lower for the medial rearfoot (2%, $P = 0.002$) and the medial forefoot (4%, $P = 0.011$) for PGP-PW. A higher value for this parameter was observed for the lateral midfoot (5%, $P < 0.001$). Peak time was significantly higher for all zones for PGP-PW ($P < 0.001$): 11% and 14% for the lateral and medial rearfoot, respectively, 24% for the forefoot and 40% and 72% for the medial and lateral midfoot, respectively. The area value was lower for PGP-PW by 11% to 13% for the rearfoot ($P < 0.001$) and by 9% ($P < 0.001$) for the medial forefoot. A higher value by 41% ($P < 0.001$) has been registered for the lateral midfoot. Peak pressure was 1% lower for the medial rearfoot ($P = 0.013$) and for the forefoot ($P < 0.002 < P < 0.033$) for PGP-WP. This parameter was 2% higher ($P < 0.001$) for the lateral midfoot.

THE EFFECT OF PELVIC BELTS ON PLANTAR PRESSURE

Figure 5 shows the four parameters for groups A (wearing a belt during pregnancy) and B (without belt) according to the time of assessment (T1 and T2). For all parameters, there was no difference between groups. Peak time increased between T1 and T2 (by 5% to 10% depending on the zones, $P = 0.045$).

THE TYPES OF BELTS

Figure 6 illustrates the four parameters depending on the type of belt (A1, belt 1; A2, belt 2) and the time of assessment (T1 and T2). For all parameters, there was no difference between

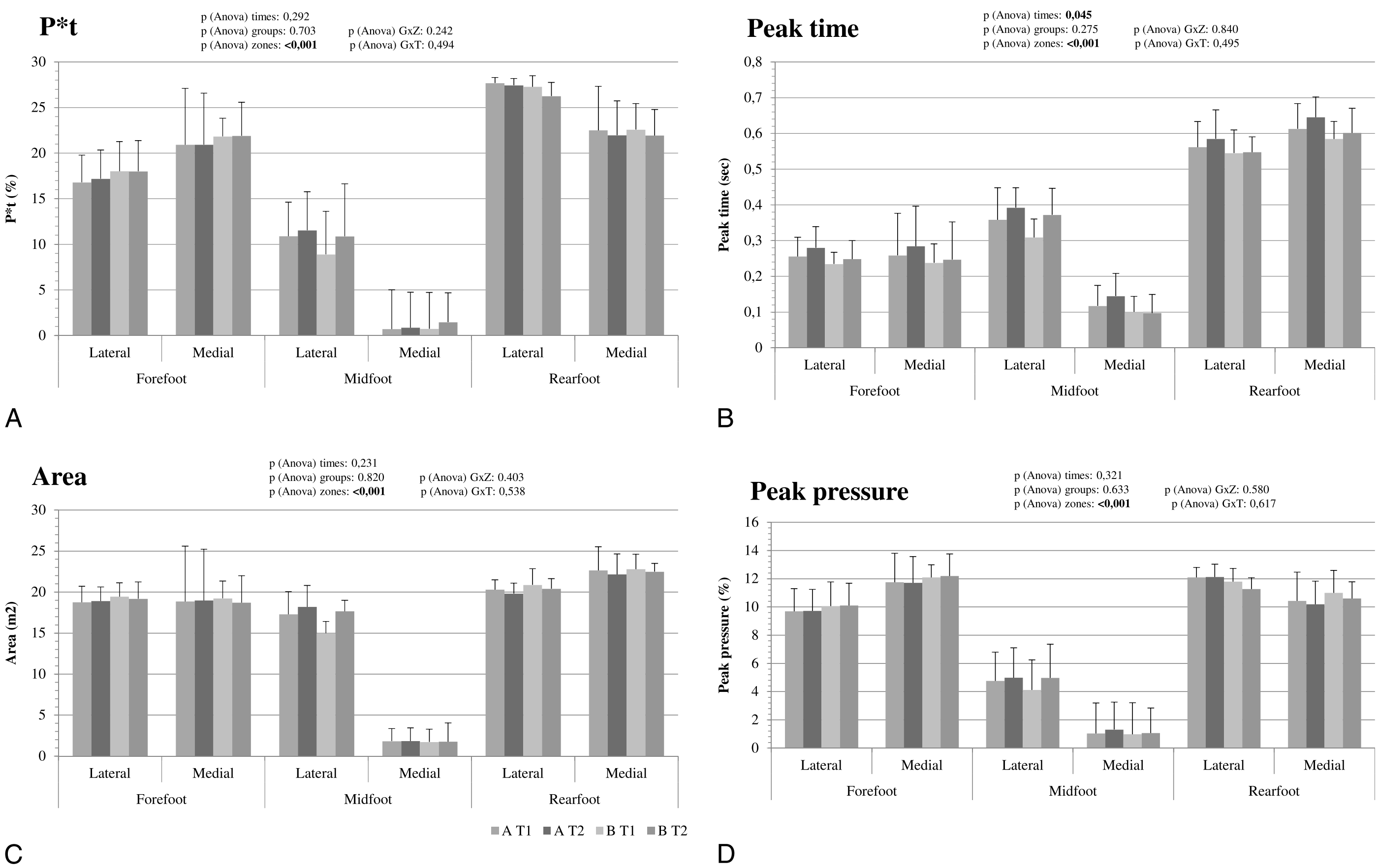

Figure 5. Mean ± SD value of the four footprint variables in the pregnant women with PGP with belt (A) and without belt (B) during pregnancy with times (T1, first evaluation; T2, second evaluation) for the six zones. A, P*t. B, Peak time. C, Area. D, Peak pressure.

groups A1 and A2. Peak time increased between T1 and T2 (by 2% to 12% depending on zones, $P = 0.005$). Peak time ($P = 0.050$) and area ($P = 0.034$) presented interactions between groups and zones. Peak time of the lateral midfoot was higher for A2 (22%), compared with A1 (17%, $P = 0.05$). The same was observed for area (21% for A1, and 22% for A2).

DISCUSSION

In this study, we investigated plantar pressure during gait in pregnant women with PGP. In addition, the long-term effects of pelvic belts and various types of belts were assessed.

PLANTAR PRESSURE IN PREGNANT WOMEN WITH PGP

Pregnant women decrease their gait velocity.[13,15,27] The same is true for pregnant women with PGP. Our study showed that the times when plantar pressure was maximum increased significantly for pregnant women with PGP, especially for the midfoot, which showed an increase by 72% for the medial side and by 40% for the lateral side. Walking more slowly, pregnant women have the opportunity to better position their feet. The aim is to unroll the foot and use more zones of the midfoot. Consequently, all areas of the foot are exploited. Similar observations were found in a previous study in healthy pregnant women. Peak time was higher in the pregnant women, at 77%, compared with 43% in the CG, for all zones, and particularly for the midfoot.[15]

Our study found a difference between pregnant women with PGP and healthy pregnant women for the medial rearfoot. The pregnant women with PGP showed a 5% higher value in this zone. This could reflect the difficulty pregnant women with PGP have when walking, as they may need more time to stabilize at the heel strike.

Women with pelvic pain had lower overall values for maximum pressure and area for the forefoot and rearfoot (medial side) compared with CG. Higher values in these parameters were observed for the lateral midfoot. Identical results were found for healthy pregnant women when compared with a CG, with the exception of overall pressure.[15]

Our results reveal differences between pregnant women with and without PGP, but they are small, suggesting that the two groups may have similar patterns of pressure distribution. The comparison between pregnant women and nonpregnant women revealed that pregnant women with and without pelvic pain showed similar gait adaptations for plantar pressure. Pelvic pain did not induce relevant changes in plantar pressure.

THE EFFECT OF PELVIC BELTS ON PLANTAR PRESSURE

The distribution of plantar pressure did not seem different between the group wearing a pelvic belt and the group that

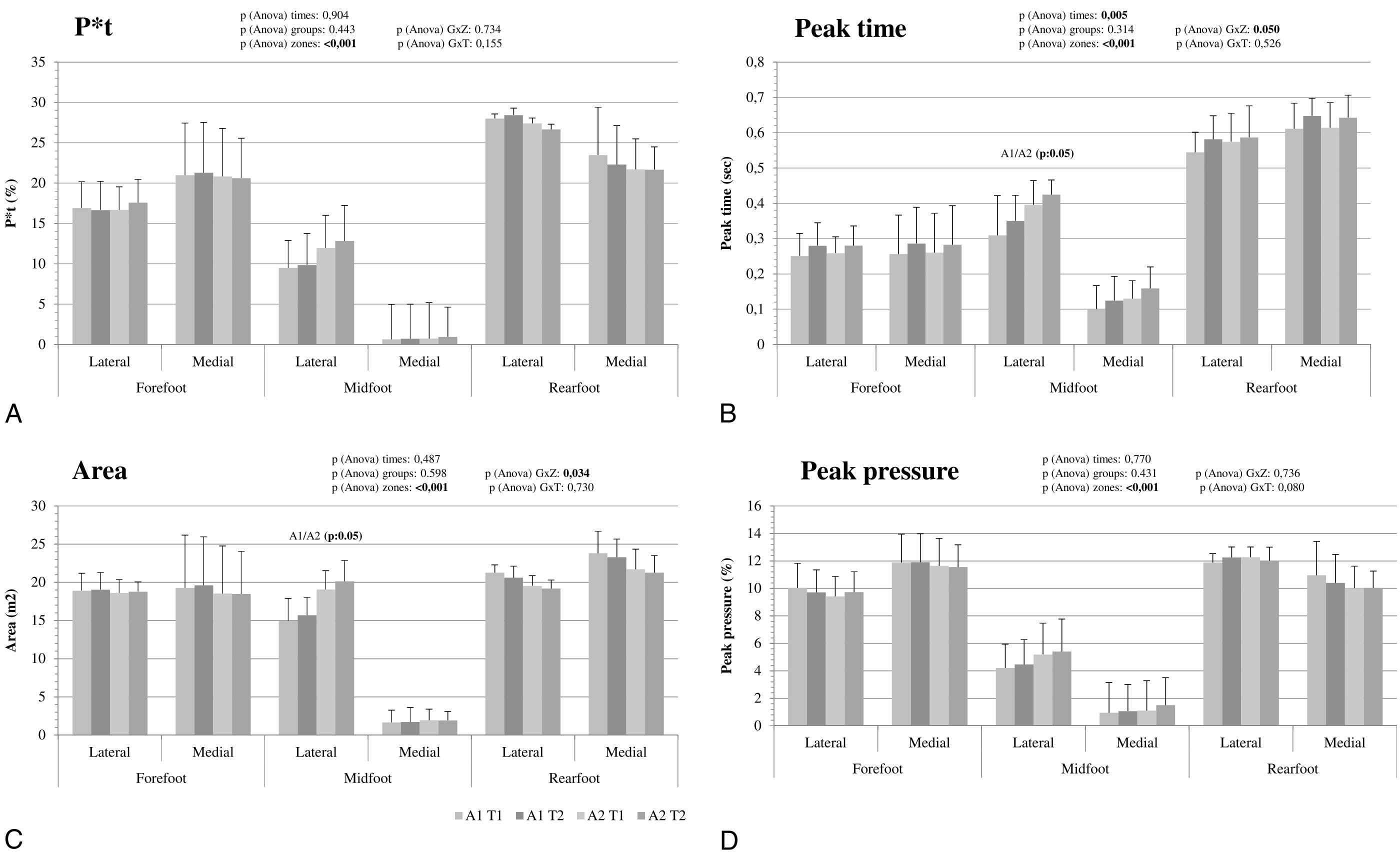

Figure 6. Mean ± SD value of the four footprint variables in the pregnant women with PGP with belt 1 (A1) and belt 2 (A2) during pregnancy with times (T1, first evaluation. T2, second evaluation) for the six zones. A, P*t. B, Peak time. C, area. D, Peak pressure.

did not. Pelvic belts seem beneficial in the short term in decreasing pelvic pain and facilitating daily activities such as walking.[3] However, in the long term, they did not seem to have an effect on plantar pressure. Thus, this study does not provide us with results that would be in favor of any clinical opinion in relation to the effect of pelvic belts on plantar pressure. However, the lack of plantar pressure evaluation with the belt in situ will be necessary to make a judgment about the effect of wearing a belt.

THE TYPES OF BELT AND PLANTAR PRESSURE

A number of studies found pelvic belts to have an analgesic effect related to proprioceptive and biomechanical effects. The literature tends to favor flexible belts that seem to have a better impact on pain.[3,28] However, this hypothesis requires confirmation because the different types of belts could have effects on global, SIJ, and back pain during pregnancy. Regarding plantar pressure, no difference was demonstrated between the two types of belt that we used. However, the lack of plantar pressure evaluation with the belt in situ will be necessary to make a judgment about the effect of wearing a belt.

For clinical practice, pelvic belts can be recommended as it was shown previously that they decrease PGP and improve functional capacity such as walking during pregnancy.[3] However, this study demonstrates that they do not have an impact on plantar pressure during gait. Therefore, this study does not support the use of a type of pelvic belt during pregnancy if the aim is to modify plantar pressures during gait.

LIMITATIONS

This study has several limitations. Our group of healthy pregnant women was recruited during prenatal gymnastics sessions. This suggests that these women were able to move freely and had a correct level of activity and knowledge of their body pattern. Therefore, our sample may not correctly represent the general population of pregnant women. This could induce a bias in our results by overestimating the abilities of this group. Furthermore, group B was a small group: there were 12 dropouts, which reduced the number of women. The main reason was a lack of motivation of the participants. Recruitment of pregnant participants for this study was complicated by the lack of time and motivation in general. The lower number of dropouts in the groups provided with a belt may be linked to the reduction of pain and disability experienced.[3] Consequently, the limited size of group B influenced the effect sizes and the power of the study. However, an intention-to-treat analysis was performed. The results showed no difference between groups with and without dropouts on the different parameters.

CONCLUSIONS

Pregnant women with PGP showed nearly the same changes in plantar pressure during gait as healthy pregnant women when compared with nonpregnant women. Pain did not induce relevant changes in plantar pressure parameters. The belts did not have an effect on plantar pressure parameters during gait in pregnant women with PGP. No difference could be detected with regards to the type of belt used (narrow and flexible or broad and rigid). However, more research needs to be done with belt in situ to investigate the effects of belts.

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