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Original Article

Center of Pressure during Gait in Pregnancy-Related Pelvic Girdle Pain and the Effect Belts

Jeanne Bertuit[1,2]* and V Feipelb[3]

[1]University of Applied Sciences and Arts Western Switzerland (HES-SO), Switzerland
[2]Laboratory of Functional Anatomy, UniversitéLibre de Bruxelles (ULB), Belgium
[3]Laboratory of Anatomy, UniversitéLibre de Bruxelles (ULB), Belgium

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***Corresponding author**

Jeanne Bertuit, University of Applied Sciences and Arts Western Switzerland (HES-SO), Switzerland,
Tel: +41 21 316 81 33;
Email: jeanne.bertuit@hesav.ch

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Abstract

Many pregnant women suffer from pelvic girdle pain (PGP) during pregnancy. Etiologies are multifactorial and affect the joint stability of the sacroiliac joint. Pelvic belts could restore stability and reduce pain during gait. The Center of Pressure (COP) is a reliable parameter to assess gait and balance. The objectives of this study were to analyze the COP during gait in pregnant women with PGP, to evaluate the effect of pelvic belts and to compare two types of belts on COP parameters.

Methods: 46 pregnant women with PGP, 58 healthy pregnant women and 23 non-pregnant women were recruited. The motor task consisted of three gait trials at different velocities on an electronic walkway. Two pelvic belts for pregnant women were used. An analysis of variance was performed to determine the effects on the COP parameters of the progression of the pregnancy, gait speed, being pregnant or not and having pain or not.

Results: Compared to the control group, pregnant women with PGP had a higher stance time, but COP displacement and velocity were lower. The COP parameters vary between pregnant women with and without pelvic girdle pain: the use of a belt during pregnancy decreases the walking velocity. No difference was found according to the type of belt.

Discussion: Differences in COP parameters during gait between pregnant women with or without PGP were minimal. Pelvic girdle pain did not affect the center of pressure. Wearing a belt during pregnancy modified the center of pressure velocity during gait in pregnant women with PGP.

Introduction

About 50% of pregnant women suffer from 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. The condition also carries a high risk of injury as the risk of falling increases by 27% during the third trimester [2,3]. The pain is significant 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 pubic symphysis [4,5]. Etiologies of PGP are multifactorial and affect the joint stability of the SIJ. The "self-locking" mechanism 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) [6]. PGP appears 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 [7,8]. Women with PGP suffer from significant impairments 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 [4].

A method 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, although this remains controversial [8-10]. A number of studies found that the use of pelvic belts decreased pain and made daily activities, such as walking, easier [4,11].

The center of pressure (COP) refers to the point at which the pressure of the body over the soles of the feet would be if it were concentrated in one spot. The position of the COP is influenced by gait speed, cadence, cycle length and the distribution of the mass of the subject [12].The mass gain during pregnancy is around 12kg and the abdominal mass increases by at least 31% [13]. It is therefore relevant to examine if the position of the COP changes during pregnancy.

The COP moves as the subject walks, and displacement speed is an indicator used to analyze the performance and quality of gait and balance [14]. However only a small number of studies have used the COP to do such an analysis. The displacement is measured at between 0, 22 and 0,27m/s in middle-aged adults and is about 0,38 m/s in young adults [15]. Pregnancy influences

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the COP parameters [16,17]. Gait velocity is lower by 22% (pregnant women: 0.99 ±0.16 m/s, control group: 1.26±0.13m/s - p<0.001) [16]. Consequently, the stance time is higher during pregnancy [16,17]. These results were explained by the fact that pregnant women, because of a disturbed proprioception and a sensation of imbalance are more cautious when walking [17].The COP velocity is lower (pregnant women: 0.28 ±0.03 m/s, control group: 0.33±0.04m/s - p<0.001) [16,17]. This, again, illustrates the caution pregnant women take when they move. The COP displacement is 5%lower compared to the control group (pregnant women: 0.19 ±0.01 m/s, control group: 0.20±0.01m/s – p=0.003) although this remains controversial [14,16,17]. These results could reflect the fact that pregnant women displace their body mass less toward the forefoot [17]. All the results suggest that pregnant women adapt their gait to maximize their stability during the support phase and to control the displacements [16-18]. To date, only one study analysed the COP in pregnant women with PGP [17]. The COP during gait was similar to that found in healthy pregnant women. Hence in this study, pelvic girdle pain did not influence COP parameters.

Considering the limited amount of literature on the subject, it is essential to improve our knowledge about changes to the center of pressure during gait for pregnant women with PGP. If the COP is different in pregnant women with pelvic pain, it would be interesting for clinical practice to be able to assess whether the COP 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 side effects and could be well-suited for pregnant women with PGP [19,20]. 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 analyse the center of pressure during gait in pregnant women with PGP. The second objective was to evaluate the effect of pelvic belts on the center of pressure. The last 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. For the first group (PGP-PW), forty-six pregnant women with PGP aged 25 to 35 years were recruited. The inclusion criteria were: women from the 18th week of pregnancy, with pain in the sacroiliac joints and / or pubic region - as verified by a set of tests during clinical examination (posterior pelvic pain provocation test, Patrick Faber's test, modified Trendelenburg test and active straight leg raise test) [21]. 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, tumours 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. The included women were randomized into two groups (A and B): Group A included thirty-eight women who had worn a belt during pregnancy. Belts were used during 9 (+/- 5) weeks of pregnancy. Group A was randomized into sub-groups (A1 / A2) in order to assess the type of belts: A1 used belt 1 (seventeen women) and A2 belt 2 (twenty-one women). Group B included twenty women who did not wear a belt. There were twelve drop-outs, which reduced the number of women in this group to eight.

For the second group (H-PW), fifty-eight healthy pregnant women aged between 24 and 31 years were included, from the 18th week of pregnancy. 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 sacroiliac joints and / or pubic area.

The third group, corresponding to the Control Group (CG), included twenty-three non-pregnant women of the same age range, free from pelvic pain and without any previous surgery.

All subjects gave written informed consent prior to participation in the study, which was approved by the Ethics Committee of the University and Hospital Erasme (Be) (number P2011/017) (Table 1).

Equipment used

The COP parameters during gait were measured using an electronic walkway (GAITRite Gold, CIR Systems, PA, USA, length: 6.1m, width: 61cm). Embedded pressure sensors form a horizontal grid. Data is sampled at a frequency of 100 Hz. The walkway is connected to a personal computer by a serial interface cable. The COP coordinates during gait were sampled using GAITRite GOLD, version 3.2b software, and processed using Excel 2007 software.

Table 1: Characteristics of the study samples.

		Groups	Number	Age(years)	Height(cm)	Week of pregnancy			Mass gain (kg)
						T1	T2	T3	
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)	-	9(5)	12(4)
H-PW			58	29(5)	166(6)	33(4)	-		10(4)
CG			23	27(5)	168(6)	-			

PGP-PW: 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: Pelvic belts. (www.thuasne.com) - a. belt 1 – b. belt 2.

Two pelvic belts for pregnant women were used

Belt 1 (Ortel-P, Thuasne) (Figure 1-a). 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). 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 1-b). 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 (Figure 1a-b).

Data collection

Each participant was invited to walk barefoot on the walkway. The motor task consisted in nine gait trials (three at each velocity). Gait speeds were self-selected, but standardized instructions were used. First, the subject was invited to walk at her preferred velocity. Then, the subjects walked at fast and slow velocity. The order of these velocities was randomised by dice throwing. Each participant was invited to walk barefoot on the GAITRite walkway.The instructions for fast velocities were "walk as fast as possible. As if you need to catch a bus" and the instructions for slow velocity were "walk slowly. As if you were shopping". A rest period was allowed between trials. To counter the methodological bias of acceleration and deceleration in gait, participants started walking 2m ahead of the walkway and finished the trial 2m after the end of the walkway.

CG, H-PW and PGP-PW walked without belt. For PGP-PW, women were evaluated at two points in time (T1/T2) for a longitudinal evaluation: at the 18th week of pregnancy (T1) and between the 34th and 38th week (T2).

Data processing

The following parameters were calculated:

Stance time (ST) was defined as ST=Tmax-Tmin, where Tmin and Tmax corresponded to the first and last instants of stance phase.

COP excursion (EXC) was defined as the sum of absolute displacements between two successive COP values in Anteroposterior (AP) or Medio-Lateral (ML) direction. Also, the distance between two successive COP values in the plane formed by AP and ML axes was computed. It is expressed in m.

COP velocity (V) corresponded to the velocity of COP displacement in anteroposterior (AP axis), medio-lateral (ML axis) direction and is defined as Vi=EXCi /(Tn+1-Tn)where "I" indicates the direction (AP or ML) and T is the time between two successive positions of the COP. It is expressed in m/s.

The following dependent variables were analyzed: stance time (sec),COP excursion(m) and COP velocity (m/sec).

Statistical Analysis

All of the statistical procedures were conducted using Statistica 5.0 software for Windows (StatSoftInc, Tulsa, Oklahoma). 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 not significantly different between sides; data from the left and right foot were, thus, averaged.

An analysis of variance for repeated measures (ANOVA) was performed for the comparison of all dependent variables between the different velocities and times (within-subject factor) and groups

Table 2: Values of COP parameters for Pregnant Women with Pelvic Girdle Pain (PGP-PW), Healthy Pregnant Women (H-PW) and Control Group (CG).

	Slow speed			Preferred speed			Fast speed			ANOVA		LSD	
	PGP-PW	H-PW	CG	PGP-PW	H-PW	CG	PGP-PW	H-PW	CG	Speeds	Groups	1	2
Stance time(sec)	0.88 (0.13)	0.90(0.15)	0.84(0.12)	0.70 (0.07)	0.72 (0.10)	0.63 (0.06)	0.54 (0.08)	0.58 (0.07)	0.51 (0.05)	<0.001	0.002	0.172	0.015
Excursion(m)													
AP	0.17 (0.02)	0.18 (0.01)	0.18 (0.02)	0.17 (0.01)	0.18 (0.01)	0.18 (0.01)	0.17 (0.01)	0.18 (0.01)	0.18 (0.01)	0.108	0.01	0.131	0.003
ML	0.07 (0.01)	0.07 (0.01)	0.07 (0.01)	0.06 (0.01)	0.06 (0.01)	0.06 (0.01)	0.05 (0.01)	0.05 (0.01)	0.06 (0.01)	<0.001	0.115		
AP-ML	0.20 (0.02)	0.20 (0.02)	0.21 (0.02)	0.19 (0.01)	0.19 (0.01)	0.20 (0.01)	0.19 (0.01)	0.19 (0.01)	0.20 (0.02)	<0.001	0.002	0.289	0.001
Velocity(m/sec)													
AP	0.21 (0.03)	0.21 (0.03)	0.23 (0.03)	0.25 (0.03)	0.25 (0.03)	0.30 (0.03)	0.33 (0.05)	0.31 (0.04)	0.36 (0.04)	<0.001	<0.001	0.348	<0.001
ML	0.08 (0.01)	0.08 (0.01)	0.09 (0.01)	0.09 (0.01)	0.08 (0.01)	0.10 (0.02)	0.10 (0.02)	0.10 (0.02)	0.12 (0.03)	<0.001	<0.001	0.052	<0.001
AP-ML	0.24 (0.03)	0.23 (0.03)	0.26 (0.03)	0.28 (0.03)	0.28 (0.03)	0.33 (0.04)	0.36 (0.06)	0.34 (0.05)	0.40 (0.05)	<0.001	<0.001	0.256	<0.001

Note: data are given as mean (SD) - Anteroposterior (AP); Mediolateral (ML) - LSD 1: PGP-PW/H-PW, 2: PGP-PW/CG.

Table 3: Values of COP parameters for Pregnant Women with Pelvic Girdle Pain with (A) and without belt (B) during pregnancy at preferred speed.

	Pregnant Women With belt			Pregnant Women Without belt			ANOVA
	T1	T2	ANOVA	T1	T2	ANOVA	Groups
Stance time(sec)	0.70 (0.07)	0.73 (0.08)	0.097	0.70 (0.09)	0.73 (0.08)	0.747	0.765
Excursion(m)							
AP	0.17 (0.01)	0.17 (0.01)	0.737	0.17 (0.01)	0.17 (0.01)	0.937	0.261
ML	0.06 (0.01)	0.06 (0.01)	0.406	0.06 (0.01)	0.06 (0.01)	0.569	0.397
AP-ML	0.19 (0.01)	0.19 (0.01)	0.512	0.20 (0.02)	0.19 (0.01)	0.81	0.157
Velocity(m/sec)							
AP	0.25 (0.03)	0.23 (0.03)	0.026	0.26 (0.02)	0.26 (0.02)	0.901	0.083
ML	0.09 (0.01)	0.09 (0.01)	0.228	0.09 (0.01)	0.09 (0.01)	0.646	0.067
AP-ML	0.27 (0.03)	0.26 (0.03)	0.033	0.29(0.02)	0.29 (0.02)	0.832	0.045

Note: data are given as mean (SD) - Anteroposterior (AP); Mediolateral (ML); T1, first evaluation; T2 second evaluation.

(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

Table 2 shows the results for the COP parameters according to the three groups. Speed influenced all parameters ($p < 0.001$) with the exception of COP ML excursion. The parameters did not show any significant differences between PGP-PW and H-PW. The comparison between PGP-PW and CG revealed several differences: for PGP-PW, stance time was higher by 7% ($p = 0.015$), COP AP and AP-ML displacement was lower by 5% ($p = 0.003$ -$p = 0.001$) and COP ML and AP velocity were lower by 8% to 16% depending on speeds.

Table 3 illustrates the COP parameters according to the groups with and without belt. Only COP AP-ML velocity ($p = 0.045$) was different between the groups. The values for group B were 4 to 10% higher than those for group A. Between T1 and T2 the values for group A decreased by 8% for AP velocity ($p = 0.026$) and by 5% for AP-ML velocity ($p = 0.033$).

Table 4 shows the COP parameters according to the type of belt worn (belt 1 and belt 2). For all parameters, we observed no difference between groups. For the group with belt 2, the COP ML velocity showed a decrease of 11% between T1 and T2 ($p = 0.049$).

Discussion

In this study, we investigated the center of pressure during gait in pregnant women with pelvic girdle pain. In addition, the effects of pelvic belts and various types of belts were assessed.

The center of pressure in pregnant women with PGP

The stance time was higher by 7% and the COP velocity was lower by 8% to 16% for the pregnant women with pelvic pain, compared to the control group. This increase is similar to the values between healthy pregnant women and the control group found in other studies, where the stance time for healthy pregnant women was higher by 5% to 12% [16,17]. The extent of COP displacement was significantly smaller for pregnant women with pelvic pain: it was 5% lower compared to the control group. The study found similar results for healthy women compared to the control group [16,17]. These data corroborate findings of previous studies on gait parameters during pregnancy [17,18,22]. Pregnant women both with and without pelvic pain reduce their gait speed in order to increase their gait stability. The results showed no difference between pregnant women with pelvic pain and healthy pregnant women, suggesting that both groups had similar COP displacement patterns during gait. Other studies also found that the presence of pelvic pain did not alter the COP parameters analyzed in this study [17].

Table 4: Values of COP parameters for Pregnant Women with Pelvic Girdle Pain with belt 1 (A1) and belt 2 (A2) during pregnancy.

	Pregnant Women With belt			Pregnant Women	With belt		ANOVA
	T1	**T2**	**ANOVA**	**T1**	**T2**	**ANOVA**	**Groups**
Stance time(sec)	0.70 (0.08)	0.72 (0.06)	0.265	0.71 (0.07)	0.74 (0.09)	0.227	
Excursion(m)							
AP	0.17 (0.01)	0.17 (0.01)	0.68	0.17 (0.01)	0.17 (0.01)	0.96	0.981
ML	0.06 (0.01)	0.06 (0.01)	0.196	0.06 (0.01)	0.06 (0.01)	0.875	0.469
AP-ML	0.19 (0.01)	0.19 (0.01)	0.916	0.19 (0.01)	0.19 (0.02)	0.424	0.783
Velocity(m/sec)							
AP	0.25 (0.04)	0.24 (0.03)	0.304	0.24 (0.03)	0.23 (0.03)	0.065	0.95
ML	0.09 (0.01)	0.09 (0.01)	0.6	0.09 (0.01)	0.08 (0.01)	0.049	1.456
AP-ML	0.28 (0.03)	0.26 (0.03)	0.38	0.27(0.03)	0.26 (0.03)	0.063	0.956

Note: data are given as mean (SD) - Anterop (AP).

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The effect of pelvic belts on plantar pressure

Between the groups who wore a belt and did not, we can observe a difference for the COP velocity: the group without belt had values that were higher by 4% to 10%. Furthermore, pregnant women who wore a belt displayed significant changes for several parameters between T1 and T2. The COP velocity showed a 5% to 8% decrease. One hypothesis could be put forward to explain these observations. The pelvic belt could compress soft tissues in the pelvic girdle area and consequently stimulate proprioceptive receptors. With more proprioceptive inputs, women wearing a belt walk more carefully and slowly to avoid pain or falling. On the contrary, women without a belt could tend to forget their pain because of lower proprioceptive inputs. This would lead them to be less cautious and inflict excessive biomechanical stress to their bodies. We did not see any significant changes in the group without belt.

The types of belt and the center of pressure

For clinical practice, pelvic belts can be recommended as it has been previously demonstrated that they decrease pelvic girdle pain and improve functional capacity, for activities such as walking during pregnancy [4,23]. However, this study reveals no difference between the two types of belt used. Therefore, this study does not support the use of a particular type of pelvic belt during pregnancy if the aim is to modify the center of pressure during gait.

Limitations

This study has several limitations: our group of healthy pregnant women was recruited during sessions of pre-natal gymnastics. This suggests that these women were able to move freely and had a correct level of activity and knowledge of their body map. Therefore, our sample may not correctly represent the general population of pregnant women. This could bias our results by overestimating the capacities of this group. Furthermore, group B was a small group: there was 12 drop-outs, which reduced the number of women. The main reason was a lack of motivation of the participants.

Conclusion

Pregnant women with PGP displayed nearly the same changes to the values of the center of pressure during gait as healthy pregnant women, when compared to non-pregnant women. Pain did not induce relevant changes in the center of pressure parameters. We suggest that the belts have a proprioceptive effect leading to a decrease of the COP velocity 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).

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