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Changes in foot posture during pregnancy and their relation with musculoskeletal pain: A longitudinal cohort study☆

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ABSTRACT

Aim: To examine foot posture changes during the three trimesters of pregnancy and to determine whether there is a relationship between these changes and the pain experienced in this period.
Methods: The study sample consisted of 62 pregnant women who attended the Gynaecology Service at Hospital Santa María del Puerto (Cádiz, Spain), between January 2013 and May 2014. In their first visit, the following sociodemographic and anthropometric data were recorded: age, weight, height and foot size. In addition, information was obtained regarding pain in the lower back, knees, ankles and feet. In this first visit, too, the Foot Posture Index (FPI) was assessed, and three subsequent controls were performed during the first, second and third months of pregnancy (termed Stages 1, 2 and 3, respectively).
Results: In Stage 1, the average foot size (i.e., shoe size) was 38.3 (SD 1.5). This size did not change between Stages 1, 2 and 3. However, body weight and BMI did present statistically significant changes during this period ($p < 0.0001$). The FPI varied during pregnancy but no relation was observed between these changes and the onset of pain.
Conclusions: During pregnancy, pronation increases but this does not appear to influence the onset of pain in the lower limbs.
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Statement of significance

Problem

Pregnancy causes physiological changes in all organs and in the locomotor system that can cause pain.

What is already known

Endocrine changes during pregnancy increase the laxity of the ligaments of the foot, which causes a gradual increase in pronation. Increased body weight and variations in body composition can increase pronation, and this has been associated with lower limb injuries.

What this paper adds

Pronation of the feet increases during pregnancy but this does not greatly influence the appearance of pains in the lower body.

1. Introduction

Pregnancy causes physiological changes in all organs and in the locomotor system.[1] During this period, body weight normally increases by 20% and therefore the foot must have sufficient flexibility so that the longitudinal arch can adapt and be able to absorb the additional weight.[2,3] From a biomechanical standpoint, the gravid uterus moves the centre of gravity forward, increasing lumbar lordosis[4] and affecting the gait, frequently causing pain.[1]

Although most of the weight gained during pregnancy is caused by the growth of the uterus, foetus and breasts, the increased volume of blood, the extravasation of liquid to extracellular tissues and greater water retention all increase the likelihood of oedema, especially during the last eight weeks of pregnancy.[5]

☆ **Study location:** This study was conducted at Catholic University of Murcia (Spain).

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Endocrine changes during pregnancy increase the laxity of the ligaments of the foot, which causes a gradual increase in pronation, especially from weeks 12 to 34 of gestation,[6,7] and also produce an increase in the length of the foot and the forefoot.[8,9] These changes may contribute to an increased risk of musculoskeletal disorders,[10] inducing complications such as rachialgia and pelvic pain, which may produce a lasting loss of functionality after childbirth[11,12] and worsen self-perceptions of health,[13] possibly giving rise to increased absenteeism.[14]

Increased body weight and variations in body composition can increase pronation, and this has been associated with lower limb injuries such as medial tibial stress syndrome[1] and patellofemoral pain syndrome.[15,16] Extremes of foot posture such as a highly pronated (flat) foot can increase the medial contact area and provoke greater medial forces and pressures.[17] Consequently there is a greater risk of injury in persons with pronated foot types than in those with normal foot types.[18]

The aim of this study is to examine foot posture changes during the three trimesters of pregnancy and to determine whether there is a relationship between these changes and the pain experienced in this period.

2. Materials and method

2.1. Sample

The study sample consisted of 62 pregnant women treated at the Gynaecology Service at Hospital Santa María del Puerto (Cádiz, Spain) between January 2013 and May 2014. The inclusion criteria applied were that the women should be less than ten weeks pregnant and in their first or second pregnancy. The following exclusion criteria were applied: having had osteoarticular surgery of the foot in the last 12 months, presenting degenerative osteoarticular disease or neuromuscular disease, having experienced severe foot trauma during pregnancy or in the previous year, not carrying the pregnancy to term, or presenting cognitive problems impeding the communication of information. The study protocol was in accordance with standard ethical and human research principles. Written informed consent for participation and publication was given by each patient, including for the publication of photographs. The study was approved by the Hospital Research Ethics Committee.

2.2. Procedure

Of the 101 pregnant women initially recruited to this study, 62 completed it and made three follow-up visits during gestation, at weeks 10–12 (first trimester), 25–27 (second trimester) and 35–37 (third trimester). In the first visit, sociodemographic and anthropometric data were obtained, including age, body weight, height and foot size, by self reporting. In addition, information was obtained on the existence of pain in the lower back, knees, ankles and feet, using a yes/no binary scale.

In every case, the Foot Posture Index (FPI) was determined by a podiatrist (Dr. Javier Vico) with an established high intra-rater reliability for FPI scoring (Intraclass correlation coefficient [ICC] = 0.91–0.98), who was blinded to the purposes of the study and to the participant's identity (Fig. 1). This analysis was

Fig. 1. The six ítems of Foot Posture Index (FPI).

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conducted with ten external participants, who were examined and then re-examined 24 h later. The FPI is a six-item clinical assessment tool used to evaluate foot posture.[19,20] It has acceptable validity[21] and good intra-rater reliability (ICC = 0.893–0.958).[22] The FPI evaluates the multi-segmental nature of foot posture in all three planes, and does not require the use of specialised equipment. Each item of the FPI is scored between −2 and +2, to give a total ranging from −12 (highly supinated) to +12 (highly pronated). The index items include talar head palpation, curves above and below the lateral malleoli, calcaneal angle, talonavicular bulge, medial longitudinal arch, and forefoot to hindfoot alignment. At each follow-up visit, the same protocol was applied.

2.3. Statistical analysis

The data obtained were analysed using SPSS 23® statistical software (SPSS Science, Chicago, IL). Descriptive statistics of the variables were used to observe the means and standard deviations of the quantitative variables obtained for each of the three measures. The Kolmogorov–Smirnov test with the Lillefors correction was used with a non-normal distribution of the population in FPI and pain and normal distribution in weight and BMI. Student's t test was applied for independent data (weight and BMI) and the Mann–Whitney U test for means with a non-normal distribution (pain and FPI). In all these tests, the statistical significance criterion of $p < 0.05$ was used. The statistical significance (p-value) of the changes with respect to the trimesters was calculated by the Mann–Whitney U test for paired data for the non-parametric quantitative variables, and by Student's t test for the parametric measures.

3. Results

The final study sample was composed of 62 Caucasian women, followed up during the three trimesters of their pregnancy. The mean age of these women was 31.0 (SD 5.1) years. In Stage 1 (first trimester) the mean foot size (taken as shoe size) was 38.3 (SD 1.5). This size did not change during the study period (Table 1).

Table 1
Age, height and shoe size.

Variable	Mean	SD	95%CI		Min	Max
Age	31	5.1	29.8	32.3	20	41
Height	163.9	6.2	162.3	165.4	152	180
Shoe size	38.3	1.5	37.9	38.7	35	43

Table 2
Variations in weight (Kg), BMI (Kg/m^2) and FPI.

Variable		Mean	SD	95%CI		Interquartile range
Weight (Kg)						
	First trimester	65.4	11.0	62.6	68.2	16.23
	Second trimester	72.0	11.3	69.1	74.9	18.56
	Third trimester	76.7	11.7	73.7	79.6	15.48
BMI (Kg/m^2)						
	First trimester	24.4	3.9	23.4	25.4	4.5
	Second trimester	26.8	4.0	25.8	27.8	4.81
	Third trimester	28.6	4.1	27.5	29.6	2.97
FPI Left						
	First trimester	2.1	3.0	1.3	2.8	8
	Second trimester	2.9	3.4	2.1	3.8	10
	Third trimester	3.9	3.6	3	4.8	11
FPI right						
	First trimester	2.1	3.3	1.2	2.9	7
	Second trimester	2.6	3.6	1.7	3.5	9
	Third trimester	3.7	4.0	2.7	4.7	10

Table 3
Correlations for variations in weight, BMI and FPI during each Stage of pregnancy.

Variable	Stage	Mean	SD	95%CI		P
Weight gain (Kg)						
	1–2	6.6	3.1	5.8	7.3	<0.0001
	2–3	4.7	3.2	3.9	5.5	<0.0001
	1–3	11.3	4.4	10.1	12.4	<0.0001
BMI gain (kg/m^2)						
	1–2	2.4	1.2	2.2	2.7	<0.0001
	2–3	1.7	1.2	1.4	2	<0.0001
	1–3	4.2	1.6	3.8	4.6	<0.0001
FPI increase Left foot						
	1–2	0.9	2.4	0.2	1.5	0.0071
	2–3	1.0	2.5	0.3	1.6	0.0037
	1–3	1.8	2.7	1.1	2.5	<0.0001
FPI increase Right foot						
	1–2	0.5	2.4	−0.1	1.1	0.0884
	2–3	1.1	2.4	0.5	1.7	0.0006
	1–3	1.6	3.1	0.8	2.4	0.0001

At baseline, the mean weight of the participants was 65.4 (SD 11) kg, and the mean BMI was 24.4 kg/m^2 (SD 3.9). In the second trimester, the corresponding values were 72 kg (SD 11.3) and 26.8 kg/m^2 (SD 4.0), respectively, and in the third (weeks 35–37 of gestation), they were 76.7 kg (SD 11.7) and 28.6 kg/m^2 (SD 4.1) (Table 2). The following FPI values were obtained: right foot, 2.1 (SD 3.3) at baseline, 2.6 (SD 3.6) in the second trimester and 3.7 (SD 4) points in the third; for the left foot, the corresponding values were 2.1 (SD 3) at baseline, 2.9 (SD 3.4) in the second trimester and 3.9 (SD 3.6) in the third (Table 2).

Statistically significant correlations were observed ($p < 0.0001$) between each of the trimesters of pregnancy (Stages 1–2, 1–3 and 2–3) and increased weight and BMI. In the right foot, the FPI increased significantly between Stages 2–3 ($p = 0.0006$) and between Stages 1–3 ($p = 0.0001$). In the left foot, the mean values for the FPI also increased significantly between Stages 1–2 ($p = 0.0071$), between Stages 2–3 ($p = 0.0037$) and between Stages 1–3 ($p < 0.0001$) (Table 3). These values are within the limits for the normal foot, according to the FPI, but a significant trend towards pronation was observed in both feet as the pregnancy progressed.

Regarding changes in FPI and the appearance of pain in the lower back, knees, ankles and/or feet, none of the measures obtained were statistically significant, except low back pain in relation to the FPI for the right foot, which approached significance, ($p = 0.063$). The remaining values were far from showing any relation (Table 4).

Table 4
Relation between FPI score between 1 to 3 and the appearance of pain in the low back and lower limbs.

Pain	Present	N	P-value Right foot	P-value Left foot
Ankle	No	57	0.938	0.668
	Yes	5		
Knee	No	55	0.433	0.884
	Yes	7		
Low back	No	50	0.063	0.139
	Yes	12		
Foot	No	47	0.797	0.535
	Yes	15		

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4. Discussion

Our results show that the study group presented no significant variations in height during gestation. Similarly, foot size, measured by shoe size, did not change between Stages 1, 2 or 3 (the first, second and third trimesters of pregnancy, respectively), which confirms the findings reported by Ramachandra et al.[23] To the best of our knowledge, very little has been published previously in this respect, and so there is no basis with which to compare these results. Paradoxically, the idea is widespread that the feet widen and therefore increase in size during pregnancy. Nevertheless, our results do not support this notion.

What our study does show is that changes in foot posture take place during pregnancy. Thus, our results reflect a pronating tendency in the right foot, with a mean value of 1.6 (SD 3.1) and in the left foot with a value of 1.8 (SD 2.7), between Stage 1 (weeks 10–12) and Stage 3 (weeks 35–37). These data coincide with those of Ribas et al.,[24] Nyska et al.,[25] Block et al.[26] and Ritchie et al.,[27] who reported increased pronation in both feet during pregnancy. In our study, the FPI, or plantar index, was determined for both feet, and our findings confirm those of Gijón[8] and Ribas,[24] that pronation increased in both the right and the left foot during pregnancy, although the trend was stronger in the left foot, and in the last weeks of gestation, which is in accordance with Ponnapula.[27]

The significantly greater increase in FPI in the left foot between the first and third trimesters may be related to the slight lateral displacement towards the right of the centre of gravity of the body, in parallel with a corresponding displacement of the uterus within the body as gestation advances.[28] Further and more specific studies should be carried out to confirm this hypothesis regarding the lateral displacement of the centre of gravity.

As expected, other study variables such as weight and BMI presented significant correlations with each stage of pregnancy. Thus, both weight and BMI increased in all three stages, and all correlations were statistically significant. These results are in line with those of Nagai et al.[29] and Caniuqueo et al.,[30] who observed that pregnancy leads to increased weight and BMI, and that this change provokes adaptations in the locomotor system.[31]

Our study also shows that pronation increases during pregnancy, corroborating the results of Segal et al.[7] and Ponnapula et al.,[28] who reported that the pronation of both feet was more pronounced in the third trimester, a change that is associated, among other factors, with the weight gain that takes place in this period.

The main limitation of this study was the loss to follow up. The decrease in the number of patients available for analysis was due to various factors: many did not want to continue the study, while others suffered a gestational loss and some experienced premature birth.

The main contribution of the present study is in its analysis of pain in relation to pronation and its extension of our understanding of the body changes that take place during pregnancy, with respect to the feet. These findings may be useful in designing specific footwear, or in informing midwives to provide advice on footwear or corrective gestation templates, in response to changes in the feet and the influence of these changes on pain during pregnancy. We found that although there was a significant increase in pronation in most cases, few of the women in our study sample (less than 25%) suffered pain in the lumbar region and lower limbs (knees, ankles and feet). In this respect, statistically significant results were only obtained in relation to the posture of the right foot, with $p = 0.063$; the remaining variables were all far from presenting any significant relation. In consequence, these results should be considered with caution. Mujin et al.,[32] Karadag-Saygi et al.[33] have reported significant increases in pain in the lower limbs during the different phases of pregnancy, but these authors did not relate this increased pain to changes in the FPI as the aetiological cause of the pain.

5. Conclusions

The main conclusion drawn from our study is that although pronation increases during pregnancy, this does not greatly influence the appearance of pains in the lower body. Moreover, foot size does not vary during the different stages of pregnancy.

Ethical statement

1) Ethical approval

The study protocol was in accordance with standard ethical and human research principles. Written informed consent for participation and publication was given by each patient, including for the publication of photographs. The study was approved by the Hospital Santa Maria del Puerto Research Ethics Committee (Date December 2012).

1) Clinical trial registry

This observational project did not require registration as a clinical trial.

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