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# Comparison of Pelvic Alignment among Never-Pregnant Women, Pregnant Women, and Postpartum Women (Pelvic Alignment and Pregnancy)

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## Abstract

**Objective:** To compare the pelvic alignment among never-pregnant women, pregnant women, and postpartum women.

**Methods:** A total of 177 nulliparous women (mean age, 18.9 ± 1.0 years), 45 pregnant women between the third and tenth month of pregnancy (mean age, 29.4 ± 3.8 years), and 124 primiparous women between the first and sixth months after delivery (mean age, 30.1 ± 4.4 years) were enrolled in this study. Pelvic alignment was measured by using the anterior superior iliac spine (ASIS) and posterior superior iliac spines (PSIS) as landmarks. The bilateral difference of pelvic tilt was defined as pelvic asymmetry (PA), the distance between bilateral ASIS was defined as the anterior width of the pelvis (AWP), and the distance between the bilateral PSIS was defined as the posterior width of the pelvis (PWP).

**Results:** PA of the pregnant group and postpartum group were significantly greater than the never-pregnant group (2.8 ± 2.4°, 4.2 ± 3.0°, and 3.7 ± 3.2°, respectively, $p < 0.001$). AWP of the pregnant and postpartum group was wider than the never-pregnant group (24.9 ± 0.3 cm, 24.1 ± 0.1 cm, and 23.6 ± 0.2 cm, respectively, $p < 0.001$). PWP of the pregnant and postpartum group was narrower than the never-pregnant group (8.2 ± 0.3 cm, 8.6 ± 0.1 cm, and 9.2 ± 0.1 cm, respectively, $p = 0.008$). In the multivariate regression analysis using never-pregnant women as the reference, pregnant and postpartum women were significantly more likely to have greater PA (β = 0.156, 0.156), wider AWP (β = 0.116, 0.202), and narrower PWP (β = -0.132, -0.147) than never-pregnant women.

**Conclusions:** We found that the alignment of the pelvis was different among never-pregnant, pregnant, and postpartum women.

**Keywords:** Nulliparous women; Pregnant women; Postpartum women; Pelvic alignment; Pelvic asymmetry; Anterior width of pelvis; Posterior width of pelvis

## Introduction

The alignment of the pelvis is an important topic in the perinatal period. During pregnancy and delivery, pelvic joints undergo changes due to the pregnancy-related hormonal influences and mechanical stresses such as pregnancy-related abdominal swelling [1]. In a previous study, pelvic alignment was associated with pregnancy-related lumbopelvic pain and pelvic floor muscle characteristics [2-5]. Therefore, pelvic alignment is important for pregnant and postpartum women.

The pregnancy-related hormones have anti-fibrotic properties and affect the ligaments and bone in the pelvic region, and the pelvic joints gain laxity [6]. Ligamentous relaxation by pregnancy-related hormones provides relative mobility of the pubic symphysis and sacroiliac joint synchondroses, resulting in widening of the birth canal and facilitating delivery [7-9]. After delivery, laxity of these ligaments gradually diminishes [1]. In some deliveries, the pubic rami separated widely because the ratio of the diameter of the maternal pelvis to the fetal head is too small to allow normal delivery [7]. A previous study showed that the distance of the interpubic gap of postpartum women was larger than that of nulliparous women [10]. Thus, alignment changes of the pelvis in the frontal plane occur during delivery.

Due to relaxation of the pelvic joints and pregnancy-related abdominal swelling, pelvic alignment in the sagittal plane changes in pregnant women. Ostgaard et al. reported that the pregnant pelvis had an anterior inclination [3], while Moore et al. reported the pelvis had a posterior inclination [4]. Thus, alignment of the pelvis in the sagittal plane has not been fully confirmed. On the other hand, Franklin et al. reported that the degree of inclination of the pelvis was different between the right and left sides during pregnancy [11]. Therefore, the pelvis might be positioned with left-right asymmetry during pregnancy. This asymmetric pelvis has been reported only in pregnant women before delivery.

There have been many studies about the pelvic alignment of women during pregnancy and delivery [3,4,7-9,11]; however, there are few studies about the differences in pelvic alignment over the course

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of pregnancy and delivery. Therefore, the purpose of this study was to compare the pelvic alignment of never-pregnant women, pregnant women, and postpartum women in a cross-sectional study.

## Methods

### Subjects

A total of 177 nulliparous non-pregnant women (mean age, 18.9 ± 1.0 years), 45 nulliparous pregnant women (mean age, 29.4 ± 3.8 years), and 124 primiparous women (mean age, 30.1 ± 4.4 years) participated in this study. Nulliparous non-pregnant women were recruited during health examinations at the university in Nara Prefecture, Japan. Nulliparous pregnant women and primiparous women (until 6 months after delivery) were recruited at an event that was held for pregnant women and mothers in Aichi Prefecture, Japan. The inclusion criteria were women without serious orthopedic disorders or neurological disease. Those with a high-risk pregnancy and a history of pelvic surgery were excluded. Personal characteristics (age, height, and weight), months of pregnancy, and months after delivery history were determined using a questionnaire.

### Pelvic measurement

In this study, a PALM palpation meter (Performance Attainment Associates, St Paul, MN) was used to measure pelvic width and tilt angle [12]. Pelvic measurements were performed by trained physical therapists. During the measurement, the participants removed their shoes and stood in an upright position with their feet spread apart and their hands crossed in front of their chest. The anterior width of the pelvis was measured by placement of the caliper tips of the PALM in contact with the bilateral anterior superior iliac spines. The bilateral distance between the anterior superior iliac spines (in cm) was defined as the anterior width of the pelvis. The posterior width of the pelvis was similarly measured as the distance between the posterior superior iliac spines. The pelvic tilt (degree) was measured bilaterally by placement of the caliper tips of the PALM in contact with the ipsilateral anterior and posterior superior iliac spines. The bilateral difference of pelvic tilt was defined as pelvic asymmetry (e.g., if the right pelvic tilt is anterior 3° and the left pelvic tilt is posterior 2°, the pelvic asymmetry is calculated as 5°). The validity estimates of PALM measurements have been shown to be excellent compared with those of radiographic measurements [13]. The PALM is a reliable, valid, and cost-effective clinical tool that has been used in some studies to measure static innominate rotation of the ipsilateral anterior superior iliac spine. Intra-reliability of the PALM has been previously shown to be 0.90 and its inter-test reliability is 0.85 [14,15].

### Statistical analysis

All statistical analyses were performed using SPSS version 20.0 (IBM Corp., Armonk, New York). We analyzed the differences of age, height, weight, pelvic asymmetry, anterior pelvic gap, and posterior pelvic gap among the never-pregnant, pregnant, and postpartum groups using one-way analysis of variance (ANOVA) and the Games-Howell post-hoc test with $p < 0.05$ considered to indicate significance. Additionally, we analyzed the differences of the anterior and posterior pelvic gap among the three groups using analysis of covariance (ANCOVA) with the Sidak correction method (alpha = 5%) adjusted by height and weight. Using ANCOVA with the Sidak correction, the analysis was considered significant when $p < 0.017$. In addition, multivariate regression analyses, adjusted for height and weight were performed to determine whether pregnancy and postpartum were associated with pelvic alignment. For this analysis, the pelvic alignment, anterior width of pelvis, and the posterior width of pelvis were dependent variables, whereas the 3 groups (dummy coded with never-pregnant group as the reference) were independent variables. These analyses were adjusted for height and weight. Standard regression values (β) were presented with a significance threshold of 0.05.

### Ethical considerations

Written informed consent was obtained from each participant in accordance with the guidelines approved by the Research Ethics Committee of Kio University and the Declaration of Human Rights, Helsinki, 1975. The protocol was approved by the Research Ethics Committee of Kio University (Approval No. H25-47)

## Results

The demographic data of the participants are shown in Table 1. Figure 1 shows the measurements of the anterior pelvic width. The anterior width of the pelvis in the pregnant group (25.0 ± 2.3 cm) and post-partum group (24.1 ± 2.3 cm) was wider than the never-pregnant group (23.6 ± 1.9 cm, $p < 0.001$). Figure 2 shows the measurements of the posterior pelvic width. The posterior width of the pregnant group (8.2 ± 2.1 cm) was the narrowest among the three groups (never-pregnant group: 9.1 ± 1.6 cm, postpartum group: 8.6 ± 2.0 cm, $p = 0.008$). Additionally, the anterior width of the pelvis in the pregnant group was significantly wider than the pre-pregnant group ($p = 0.001$) and the posterior width of the pelvis of the pregnant group was also significantly narrower than the never-pregnant group ($p = 0.016$) on ANCOVA.

On one-way ANOVA, pelvic asymmetry of the pregnant and postpartum group were significantly greater than the never-pregnant group (4.2 ± 3.0°, 3.7 ± 3.2°, and 2.8 ± 2.4°, respectively, $p < 0.001$) (Figure 3). Additionally, the Games-Howell post-hoc test indicated that the pelvic asymmetry of the never-pregnant group was significantly smaller than that of the pregnant group ($p = 0.009$) and postpartum group ($p = 0.019$).

To examine the association between pelvic alignment and confounding factors, we carried out a multiple regression analysis

| Variables | Total | | Never-pregnant | | Pregnant | | Postpartum | | P value |
|---|---|---|---|---|---|---|---|---|---|
| | (n = 346) | | (n = 177) | | (n = 45) | | (n = 124) | | |
| Age (years) | 24.3 | ± 6.3 | 18.9 | ±1 | 29.4 | ± 3.8§ | 30.1 | ±4.4§ | < 0.001† |
| Height (cm) | 158 | ± 5.3 | 158 | ±5.3 | 159 | ± 5.1 | 158 | ±5.4 | 0.404 |
| Weight (kg) | 52.9 | ± 7.4 | 52.5 | ±7.2 | 57.3 | ± 7.7§ | 52.1 | ±7.2* | < 0.001† |
| months of pregnancy | - | | - | | 6.6 | ± 1.8 | - | | - |
| months after delivery | - | | - | | - | | 4.6 | ±1.3 | - |

**Table 1:** Comparison of characteristics among the three groups.
Note: Values are shown as mean ± SD.
†: $P < 0.01$
§: Significant difference from the never-pregnant group.
*: Significantly different from the pregnant group.

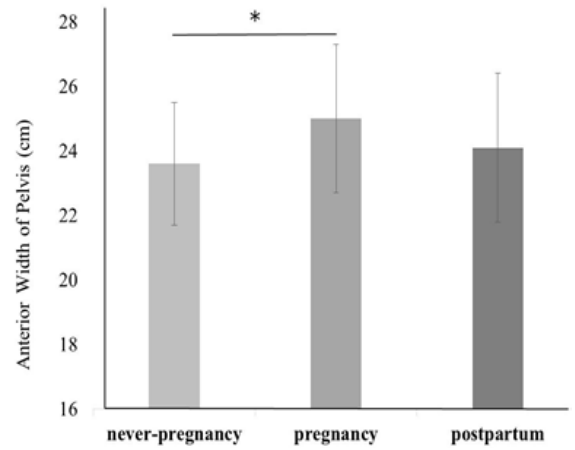


**Figure 1:** Comparison of the anterior width of the pelvis between the groups by ANCOVA adjusted by height and weight. There were significant differences in the anterior width of the pelvis among the three groups. (P= 0.002) *P < 0.017.

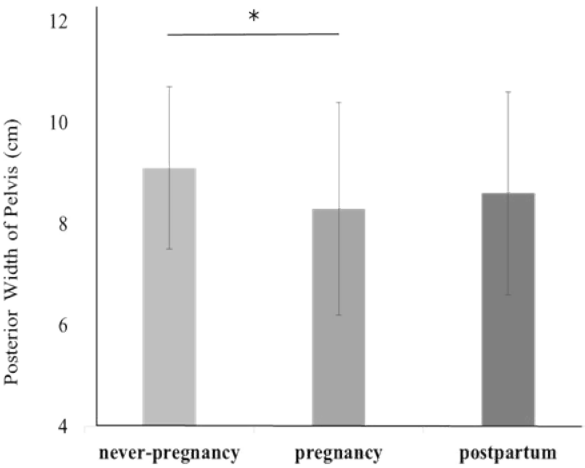


**Figure 2:** Comparison of the posterior width of the pelvis among the groups by ANCOVA adjusted by height and weight. There were significant differences in the posterior width of the pelvis among the three groups. (P=0.008) *P<0.017.

using pelvic alignment as a dependent variable (Table 2). We found that pregnancy and postpartum were significant and independent determinants of pelvic asymmetry (β = 0.156 and 0.156, p = 0.006 and 0.005, respectively) and the posterior width of pelvis (β = -0.132 and -0.147, p = 0.011 and 0.019, respectively). In addition, pregnancy, postpartum, and weight were also significant and independent determinants of the anterior width of pelvis (β = 0.202, 0.116, and 0.234; p < 0.001, = 0.031, and <0.001, respectively).

## Discussion

The results of this study show that pelvic alignment is different among never-pregnant women, pregnant women, and postpartum women. The anterior width of the pelvis of pregnant women was wider than that of never-pregnant women; however, the posterior width of pregnant women was narrower than that of never-pregnant women. The pelvic asymmetry of pregnant women and postpartum women was higher than that of never-pregnant women. Pregnancy and postpartum were positively associated with pelvic asymmetry and the anterior width of pelvis. On the other hand, pregnancy and postpartum were negatively associated with the posterior width of pelvis. Our findings that the width of the pelvis was different between never-pregnant women and pregnant women, and the pelvic asymmetry was different between never-pregnant women and both pregnant and postpartum women but was not different between pregnant women and postpartum women are entirely new.

In this study, we show that the anterior width of the pelvis of pregnant women is wider than that of never-pregnant women but the posterior width of the pelvis of pregnant women is narrower than that of never-pregnant women. Pregnancy and postpartum are significant factors contributing to the anterior and posterior width of the pelvis. During pregnancy, pelvic joints loosen [16]. Previous studies showed that there was a mean increase of 7 mm in vertical stretching and of 3 mm in lateral stretching of the pubic symphysis during pregnancy [17]. Thus, during pregnancy, the interpubic gap is separating [6]. In the loose pelvis, the left-right ilia might move forward with the growth of the fetus. With forward opening of the pelvis, it is possible that the pubic symphysis is extended and the sacroiliac joints are affected with

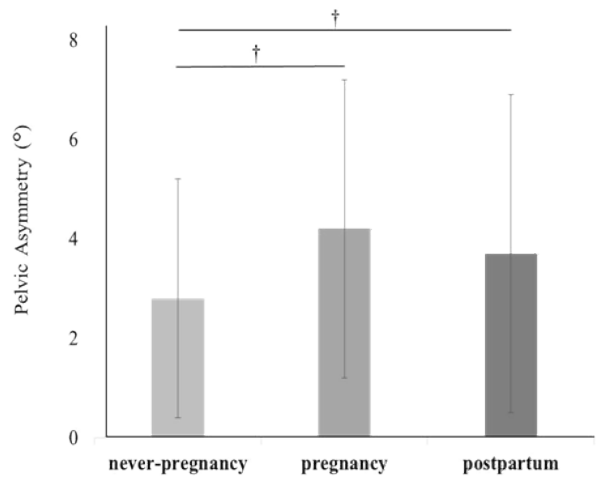


**Figure 3:** Comparison of the pelvic asymmetry among the groups by ANOVA. There were significant differences in the pelvic asymmetry among the three groups. (P=0.002).

| Variables | Pelvic Asymmetry | | Anterior Width of the Pelvis | | Posterior Width of the Pelvis | |
|---|---|---|---|---|---|---|
| | Standard regression value (β) | P | Standard regression value (β) | P | Standard regression value (β) | P |
| Never-pregnant | 1 [Reference] | - | 1 [Reference] | - | 1 [Reference] | - |
| Pregnant | 0.156 | 0.006‡ | 0.202 | <0.001‡ | -0.132 | 0.011† |
| Postpartum | 0.156 | 0.005‡ | 0.116 | 0.031† | -0.147 | 0.019† |
| Height | 0.112 | 0.056 | -0.061 | 0.278 | 0.036 | 0.536 |
| Weight | -0.037 | 0.53 | 0.234 | <0.001‡ | 0.004 | 0.948 |

**Table 2:** Multiple regression analyses for the association of factors with pelvic alignment in the 3 groups
The analyses for pelvic alignment were adjusted for height and weight.
†: P < 0.05; ‡: P< 0.01

stenoses. On the other hand, the anterior and posterior width of the pelvis of postpartum women was not significantly different from never-pregnant women and pregnant women. In a previous study, the pubic symphysis and sacroiliac joints were found to separate during delivery [18], and the interpubic gap of postpartum women was wider than that of nulliparous women [10]. The participants of that study were 2 to 12 days postpartum [10]; however, in this study, the postpartum women were measured 1 to 6 months after delivery. The symphysis pubis and sacroiliac joints return to normal 4 and 12 weeks postpartum [1,18-21]. Therefore, the width of the pelvis of postpartum women might recover shortly after delivery.

Pelvic asymmetry of the pregnant postpartum women was larger than that of never-pregnant women. A previous study reported that during pregnancy, the sacroiliac joints have asymmetric laxity [22], and the pelvic tilt during the third trimester of pregnancy is more anteverted than during the first trimester [11]. In healthy adults, carrying baggage on only one shoulder and cross-legged sitting has an effect on the pelvic tilt [23,24]. Therefore, pelvic asymmetry might become higher as the pregnancy progresses because of asymmetric laxity of the sacroiliac joints and daily habitual asymmetric load carrying, such as placing baggage on only one shoulder, cross-legged sitting, or perhaps due to the fetal position. Pelvic asymmetry of the postpartum group was also larger than that of the never-pregnant group. After delivery, the influence of relaxin continues for 3-5 months [6], suggesting that pelvic laxity might continue after childbirth. In this study, a mean 4.6 months elapsed between delivery and pelvic measurements. Therefore, postpartum women might still have pelvic laxity and pelvic asymmetry.

This study shows that it is possible that the pelvis of pregnant women opens forward. The pubic symphysis might be extended and sacroiliac joints might be affected with stenoses. Pregnant women frequently complain of pubic and sacroiliac pain [16]. Pubic pain might be caused by this extended pubic symphysis and sacroiliac pain could be caused by sacroiliac stenosis. A previous study reported that pelvic alignment is associated with low back pain [25,26]. Low back pain is one of the most common causes of discomfort during pregnancy [27]. It is possible that pelvic asymmetry is a risk factor associated with pregnancy-related low back pain. Additionally, further studies are required to determine the associations between pelvic alignment and pelvic pain and between pelvic alignment and daily habitual asymmetric load carrying, a method for treatment. Results from these studies may help in taking countermeasures against low back pain by involving medical staff and the patient [28].

## Limitations

There were several limitations to the current study. First, this study was cross sectional in design and is not a longitudinal observational study. Therefore, we need further research to investigate the issues of casual relationships. Second, the never-pregnant women were recruited from a different setting than the other groups. This is because pregnant and postpartum women were recruited at the event that was targeted at only pregnant women and mothers. Third, we have not measured other factors that may affect pelvic alignment, such as the level of pregnancy-related hormones, muscular strength, physical flexibility, months of pregnancy, and months after delivery.

## Conclusion

The current study revealed that the anterior width of the pelvis of pregnant women was wider but the posterior width of the pelvis was narrower than that of never-pregnant women. The pelvic asymmetry of pregnant and postpartum women was larger than that of never-pregnant women. Our study showed that pelvic alignment was different among the three groups. Our results indicate that it is necessary to study pelvic alignment in a longitudinal study and to explore the association between pelvic asymmetry and pregnancy-related pelvic pain. This study provides insight into the necessity of research on the association between anterior and posterior width of the pelvis and pelvic asymmetry and pelvic pain.

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