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The relationship between the asymmetric pelvic inclination in the frontal plane and the pelvic pain during pregnancy.

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Abstract

In the third trimester of pregnancy, many women complain of pain around the sacroiliac joints, and the laxity of the sacroiliac joint has been thought to be an associating factor which cause the pain. The measurement of the laxity of the sacroiliac joint using a Doppler imaging of vibration has been established and has shown that asymmetric laxity was one of the leading factors of pelvic pain during pregnancy. However, a more accessible method is needed to measure the pelvic laxity in the clinical setting. The purposes of this study were1) to introduce a method for distinguishing the position of the pelvis in the frontal plane, 2) to measure the pelvic position in different standing conditions among pregnant and non-pregnant women, and 3) to investigate the relationship between the asymmetric position of the pelvis and pelvic pain. This study demonstrated that 1) the method which we utilized might be useful to determine the pelvic position in the frontal plane, 2) the pelvic position of pregnant women were significantly inclined in standing, but the movements of the pelvis do not change as a result of pregnancy, and 3) the pelvis of the pregnant women with pelvic pain was significantly inclined to the non-elevated side.

Key words:

pelvic inclination, asymmetry, pregnancy.

Introduction

In the third trimester of pregnancy, over 50 to 80% of pregnant women complain of pain around the sacroiliac joints (SIJ)[1-7]. Many investigations tried to understand the mechanisms which lead to pelvic pain[1-8] and some researchers have found some of the factors related to pelvic pain. Ostgaard et al. reported that the pregnant women who have low laxity in their peripheral joint in the 12th week develop back pain later in pregnancy[2]. Kristiansson et al. reported that a significant correlation was found between mean serum relaxin levels during pregnancy and low back pain occurring during late pregnancy[3]. We also reported that the width of the pelvis is one of the physical changes during pregnancy, and, as the pregnancy advances, the width also increases, and we thought this change occurred because of the secretion of the hormone relaxin and the pressure of the fetus inside[9, 10]. The measurement of the laxity of the SIJ has already been established using Doppler imaging of vibrations (DIV)[11]. A study which used DIV has reported that women who feel pelvic pain tend to have asymmetric laxity in the SIJ[12], and the asymmetric laxity of the pelvis was suggested as one of the leading factors in pelvic pain during pregnancy. Using DIV in each clinical setting would be ideal to screen pregnant women to detect the laxity of SIJ in the hospital. However, it is not easy to use DIV, because a special system and procedure are needed to measure the laxity[13]. Therefore, it is necessary to explore a more accessible method

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to measure the laxity in the clinical setting. In our previous study we introduced a method to measure the position of the pelvis in the frontal plane and we found that the laxity of the SIJ may be measured by the angle between the bilateral posterior superior iliac spines[9]. However, the method needed some improvement to distinguish the position of the pelvis more clearly.

Standing is one of the positions which pregnant women frequently find difficult in daily living[14]. Standing for long periods is one of the behaviors that should be avoided during pregnancy, as continuous loading is harmful to a lax pelvis[8), 15]. Therefore studying the standing posture will give us useful information about what is happening in the SIJ. The purposes of this study were 1) to introduce a method to distinguish the position of the pelvis in the frontal plane, 2) to measure the pelvic position in different standing conditions for pregnant and non-pregnant women, and 3) to investigate the relationship between asymmetric position of the pelvis and pelvic pain.

Materials and Methods

The subjects were eight pregnant women in their 36th week of pregnancy as the pregnant group, and eight women with no experience of pregnancy as the non-pregnant group. The subjects of the pregnant group were recruited from an outpatient obstetric department of a general hospital. The inclusion criteria for the subjects were 1) age between 20 to 40 years, 2) no complications, 3) no obesity, 4) no history of pelvic and hip joint problems, 5) not having multiple pregnancies for the pregnant group, and 6) ability to obtain an informed consent. This study was approved by the ethics committees of Konan Women's University and Saiseikai Hyogoken Hospital.

Prior to measurement, an informed consent was obtained from the each subject after an explanation of the procedure for the study was given. The subjects completed the questionnaire that included questions on their profiles: age, height, weight before pregnancy, and weight at the 36th week of pregnancy, and pelvic pain. The location of the pain was determined by a pain drawing. Intensity of the pain was obtained by a Visual Analog Scale (VAS).

For the measurements of the pelvic position, a marker was placed on each of five landmarks: the spinal processes of L2, L4, and S2, and the bilateral posterior superior iliac spines (PSIS) (Figure 1). The subjects were instructed to stand on the five conditioned surfaces: feet were placed on the surface of (1) a flat height, (2) 1 cm lower on the left, (3) 2 cm lower on the left, (4) 1 cm lower on the right, and (5) 2 cm lower on the right (Figure 1). Then photographs were taken of the subject's back with a digital camera (RICHO R10, Japan) located 250cm away from the subject. A line parallel to the bottom of the back wall used in the photographs was considered as the horizontal line and was confirmed with a leveling instrument. To compensate for a slant in the photograph, the line was corrected to obtain a level horizontal line (0 degree). The angle between two connecting lines was measured as the pelvic inclination angle; one line connected both PSISs (PSIS line), and the other line was parallel to the horizontal line. The PSIS line was used as the moving line. The measurements of the angle were conducted 3 times, and the average value was calculated. The angle was considered as minus when the PSIS line moved superior (higher) to the horizontal line, and it was considered as plus when the PSIS line moved inferior (lower) to the horizontal line (Figure 2). The measurement of the pelvic inclination angle was measured with a Scion Image (Scion Co., USA).

Statistical analysis

For analyzing the pelvic inclination angles the side of the pelvis which was elevated in standing on

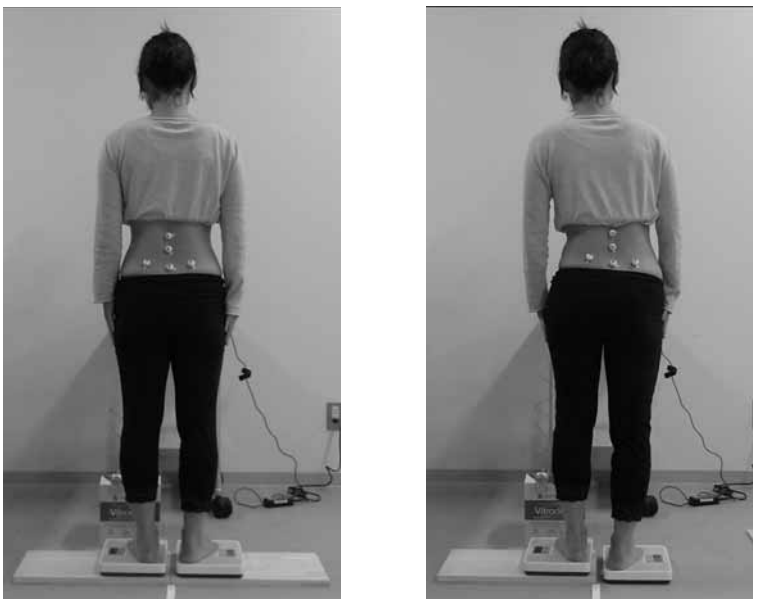

Figure 1 Measurement of posture

The markers were placed on 5 landmarks: the spinal process of L2, L4, and S2, and the bilateral posterior superior iliac spines (PSIS). The photographs were taken under five conditions; feet were placed on (1) an flat surface (left picture), (2) 1 cm lower on the left, (3) 2 cm lower on the left, (4) 1 cm lower on the right, and (5) 2 cm lower on the right (right picture).

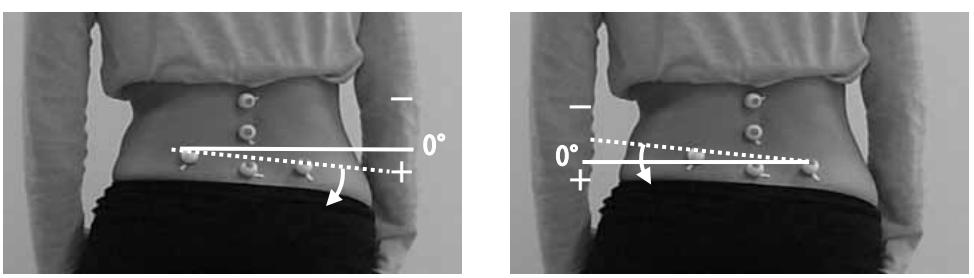

Figure 2 Measurement of the pelvic inclination angle

The photograph shows the measurement of the pelvic inclination angle on the elevated side (left), and non-elevated side (right). Pelvic inclination angles were the angle formed by 2 lines; the dotted line connected both PSISs (PSIS line), and the line which is parallel to the horizontal line confirmed in the photograph (white line). The PSIS line was a moving line (up (-), down (+)).

the flat surface was considered as the elevated side, and the opposite side was considered as the non-elevated side. A one-way analysis of variance (ANOVA) was used to compare the pelvic inclination angles under three conditions on the elevated and non-elevated sides: standing on a flat surface, 1 cm lower on one side, and 2 cm lower on one side. Tukey-Kramer's HSD test was then used as the post hoc procedure to explore the significant differences between conditions for each side. The amount of the angle change between the conditions was calculated on each side and considered as the change of the pelvic inclination angle. The amount of the angle was calculated by subtracting the angle of the flat surface from the angle of the lower surface, and the values were expressed in absolute values. Left-right differences of the pelvic inclination angle were calculated by subtracting the angle of the elevated side from the angle of the non-elevated side for the same condition, and the values were expressed in absolute

values. The pelvic inclination angle and the change of the angle between the conditions were compared between the pregnant and non-pregnant groups, and the pregnant women with pelvic pain and without pelvic pain groups. Pelvic pain included the pain in the posterior pelvis and/or in the symphysis pubis. A probability level of <0.05 was adopted as the indicator of statistical significance for all tests. The T-test was used for the pregnant and non-pregnant groups, and the Wilcoxon test was used for the pregnant women with and without pelvic pain groups. All statistical procedures were performed using JMP 8.02.

Results

Subjects

The profile of the subjects is shown in Table 1. The pregnant group was significantly taller than the non-pregnant group. There were no significant differences in age, weight, and BMI for the pregnant and non-pregnant groups. There were no significant differences in age, height, weight, and BMI for the pregnant women with and without pelvic pain. The locations of the pain obtained from the pregnant women were all around symphysis pubis. The non-pregnant women complained of pain around the bilateral SIJs. The intensity of the pain and elevated side of the pelvis are shown in Table 2.

The pelvic inclination angle for the different conditions

The pelvic inclination angles of all subjects were inclined in standing on the flat surface. The pelvic inclination angles under each condition in the pregnant and non-pregnant groups are presented on Table 3. A post hoc analysis revealed that the pelvic inclination angles for each condition were significantly different in the non-pregnant group. In the pregnant group, there was no significant difference in the pel-

Table 1 Comparison of the subjects' characteristics

			Pregnant women	
	Pregnant n=8	Non-pregnant n=8	Pelvic pain (+) n=4	Pelvic pain (-) n=4
Age (yrs.)	30.63 (6.72)	27.38 (3.85)	32.75 (8.22)	28.50 (5.07)
Height (cm)	163.00* (3.30)	155.88 (3.04)	163.25 (1.50)	162.75 (4.79)
Weight (kg)	51.13 (4.67)	50.26 (7.82)	50.50 (5.45)	51.75 (4.50)
BMI	19.24 (1.68)	20.69 (3.24)	18.90 (1.76)	19.58 (1.78)

*significantly different between the groups P<0.05
( ): standard deviation

Table 2 Intensity of the pain and the elevated side of the pelvis

	Intensity (VAS)	Elevated side	Intensity (VAS)	VAS	Elevated side
P1	1.30	right	NP1	0.00	left
P2	0.00	left	NP2	0.00	left
P3	0.00	right	NP3	0.70	left
P4	7.70	left	NP4	2.20	left
P5	6.05	right	NP5	0.00	right
P6	0.00	left	NP6	0.00	right
P7	0.00	left	NP7	0.00	left
P8	1.15	left	NP8	0.00	right

P: pregnant women
NP: non-pregnant women

The side of the pelvis which was elevated in standing on the flat surface was considered as the elevated side, and the opposite side was considered as the non-elevated side.

Table 3 The pelvic inclination angles for each condition of pregnant and non-pregnant women

	Elevated side				Non-elevated side			
	Flat surface (degree)	1 cm lower (degree)	2 cm lower (degree)	ANOVA (post hoc)	Flat surface (degree)	1 cm lower (degree)	2 cm lower (degree)	ANOVA (post hoc)
Pregnant n=8	-3.01* (1.74)	-0.27 (1.69)	1.74* (1.30)	†† (§)	3.01* (1.07)	4.54 (1.57)	6.50 (1.55)	†† (§ §)
Non-pregnant n=8	-1.76 (1.04)	0.90 (1.26)	3.53 (1.23)	†† (§)	1.58 (1.05)	4.41 (1.85)	6.75 (1.62)	†† (§)

( ): standard deviation

The side which was elevated in standing on the flat surface was considered as the elevated side. ANOVA was used to compare the pelvic inclination angle under three conditions on each side. Turkey-Kramer's HSD test was used to explore the significant difference between conditions. T-test was used to compare the pregnant and non-pregnant group.
*statistically significant difference between groups P<0.05
†† statistically significant difference among condition P<0.01
§ statistically significant difference between each condition P<0.05
§ § statistically significant difference between each condition P<0.05 except between 1cm lower and equal surface

Table 4 Changes of pelvic inclination for pregnant and non-pregnant women

	Elevated side		Non-elevated side	
	Flat surface to		Flat surface to	
	1 cm lower (degree)	2 cm lower (degree)	1 cm lower (degree)	2 cm lower (degree)
Pregnant n=8	2.73 (0.99)	4.74 (1.10)	1.53* (0.80)	3.50** (0.75)
Non-pregnant n=8	2.66 (0.59)	5.30 (0.68)	2.64 (1.06)	4.99 (1.01)

*statistically significant difference between groups P<0.05
**statistically significant difference between groups P<0.01
( ): standard deviation

The change of the pelvic inclination angle is the amount of the angle calculated by subtracting the angle of the flat surface from the angle of the lower surface.

Table 5 Left-right differences of the pelvic inclination angle and the change of the pelvic inclination angle for pregnant and non-pregnant women

	The pelvic inclination angle		The change of pelvic inclination angle	
	1 cm lower (degree)	2 cm lower (degree)	Flat surface to 1 cm lower (degree)	Flat surface to 2 cm lower (degree)
Pregnant n=8	5.03 (2.80)	4.76 (2.69)	1.32 (1.61)	1.41 (1.45)
Non-pregnant n=8	3.51 (3.02)	3.27 (2.37)	1.09 (0.81)	0.68 (0.51)

( ): standard deviation

Left-right difference of the pelvic inclination angle is calculated by subtracting the angle of the elevated side from the angle of the non-elevated side for the same condition.

vic inclination angle between standing on a flat surface and the 1 cm lower surface on the non-elevated side of the pelvis.

The comparison between the pregnant and non-pregnant groups

The comparisons of the pelvic inclination angles between the pregnant and non-pregnant group for each side are presented in Table 3. There was a significant difference in the pelvic inclination angles between the pregnant and non-pregnant group in standing on a flat surface and 2 cm lower on the elevated side. The changes in the pelvic inclination angles for the conditions are presented in Table 4. There was no

significant difference in the change of the pelvic inclination angle for the elevated side between the groups. The change of the pelvic inclination angle was significantly smaller on the non-elevated side in the pregnant group. Left-right differences of the pelvic inclination angles in pregnant and non-pregnant groups are presented in Table 5. There were no significant differences between the groups in all of the conditions.

The comparison between the pregnant women with and without pelvic pain

The pelvic inclination angles of the pregnant women with and without pelvic pain are presented in Table 6. The pelvic inclination angle for the group with pelvic pain was significantly larger than the angles for the pregnant women without pelvic pain when standing on the 1 cm and 2 cm lower surface on the non-elevated side. The changes in the pelvic inclination angles are presented in Table 7. There was no significant difference in the changes of the pelvic inclination angles between the two groups. Left-right differences of the pelvic inclination angle in the pregnant women with and without pelvic pain are shown in Table 8. Left-right difference in the pelvic inclination angle was significantly larger in the women with pelvic pain for the 1 cm lower condition. Left-right difference in the change of the pelvic inclination angle was not significantly different for both 1 cm lower and 2 cm lower conditions.

Discussion

A method to distinguish the position of the pelvis in the frontal plane

In our previous study, we introduced a method to measure the pelvic position in the frontal plane, and we found that the change in the pelvic position in the horizontal direction during pregnancy resulted from an increased width of the pelvis. However, there was no significant difference in the pelvic inclination between the pregnant and non-pregnant groups in our previous study. It remained unclear whether the change of the pelvic position in vertical direction would occur during pregnancy. We only measured the static standing position in our previous study, and we found that a modification of the method was necessary to distinguish the vertical change of the pelvic position more clearly. Therefore, we modified the previous method by changing the height of the surface to 1cm and 2cm lower on one side. The result showed there was a significant difference between the conditions for both groups. The result of the post hoc analysis in the non-pregnant group suggested that lowering the surface on one side could result in a vertical shift of the pelvis. However, in the pregnant group, the post hoc analysis revealed that the pelvic inclination angle was not significantly different between the flat surface and 1cm lowered surface on the non-elevated side. This result suggested that lowering the surface by 2cm would be better than 1cm to evaluate the pelvic position on the non-elevated side for the pregnant women. The method utilized to measure the pelvic inclination angle by lowering the surface 2cm provided the possibility to evaluate and distinguish the pelvic position more precisely.

The pelvic inclination angle in pregnant and non-pregnant women

In our previous study, the result of the pelvic inclination angles at the 36th week of pregnancy showed that there was no significant difference between the pregnant and non-pregnant groups, but measurements were conducted only in standing on a flat surface. For our present study, the subjects were positioned in different conditions, and their pelvic inclinations were observed for the elevated and non-elevated sides of the pelvis. The pelvic inclination angle on the elevated side showed a significant difference between the pregnant and non-pregnant women in standing on a flat surface and 2cm lower surface. However, the movement of the pelvis (i.e. the change of the pelvic inclination angle) was not significantly different

Table 6 The pelvic inclination angle for each condition for pregnant women with and without pelvic pain

	Elevated side			Non-elevated side		
	Flat surface (degree)	1cm lower (degree)	2 cm lower (degree)	Flat surface (degree)	1 cm lower (degree)	2 cm lower (degree)
Pelvic pain (+) n=4	-3.71 (0.64)	-1.27 (0.91)	1.11 (1.11)	3.71 (0.65)	5.60* (0.84)	7.65* (0.87)
Pelvic pain (-) N=4	-2.31 (0.98)	0.73 (1.79)	2.38 (1.26)	2.31 (0.98)	3.48 (1.43)	5.35 (1.17)

*statistically significant difference between groups P<0.05
( ): standard deviation

Table 7 The changes of the pelvic inclinations between conditions for the pregnant women with and without pelvic pain

	Elevated side		Non-elevated side	
	Flat surface to		Flat surface to	
	1 cm lower (degree)	2 cm lower (degree)	1 cm lower (degree)	2 cm lower (degree)
Pelvic pain (+) n=4	2.44 (0.31)	4.81 (0.99)	1.89 (0.20)	3.93 (0.50)
Pelvic pain (-) n=4	3.02 (1.39)	4.66 (1.36)	1.17 (1.06)	3.08 (0.76)

*statistically significant difference between groups P<0.05
( ): standard deviation

Table 8 Left-right differences of the pelvic inclination angle and the changes of the pelvic inclination angle for pregnant and non-pregnant women

	The pelvic inclination angle		The change of pelvic inclination angle	
	1 cm lower (degree)	2 cm lower (degree)	Flat surface to 1 cm lower (degree)	Flat surface to 2 cm lower (degree)
Pelvic pain (+) n=4	6.87* (1.74)	6.54 (1.90)	0.55 (0.49)	1.22 (1.09)
Pelvic pain (-) n=4	3.20 (2.52)	2.97 (2.19)	2.08 (2.07)	1.60 (1.90)

*statistically significant difference between groups P<0.05
( ): standard deviation

between both groups. This result suggested that the pelvises of the pregnant women were inclined more than the pelvises of the non-pregnant women, and it was confirmed by measuring the pelvic inclination angle in standing on the flat surface and 2cm lowered surface. On the non-elevated side, a significant difference was not found in standing on the surface lowered 1cm and 2cm. Smidt et al. reported the amount of the movement in frontal plane ranged 4 to 11 degrees during the extreme flexion and extension movement of the hip joint measuring with CT scan on fresh cadaver[16]. The pelvic inclination angles obtained on this study were about 4 degree in 1cm lowered surface and about 6 degrees in 2cm lowered surface in both groups. The results we obtained lowering the height of the surface might be close to the maximal angle of SIJ. We also need to reconsider the standing position which is appropriate to distinguish the pregnant women. Left-right differences of the pelvic inclination angle and its change did not show the significant difference between groups, and left-right difference may not be a distinguishing characteristic between the pregnant and non-pregnant groups.

The comparison between pregnant women with and without pelvic pain

The pregnant group was divided into two groups: the pregnant women with and without pelvic pain by the existence of the pelvic pain. When the subjects were standing on the flat surface, there was not a significant difference between the groups in pelvic inclination angle. However, the pelvic inclination angle for the pregnant women with pelvic pain declined significantly when lowering the surface on the non-elevated side. We thought that the pelvis of the pregnant women with pelvic pain may have more lax joint, and the SIJ and the tissues around it on the non-elevated side were elongated by the hanging weight of the lower extremity when standing on the conditioned surface. The movement of the pelvis did not show the significant difference between the groups. Therefore the position rather than the movement of the pelvis thought to be useful on evaluating the pregnant women. Damen et al. pointed out asymmetric laxity which is associated with the pelvic pain by investigating left-right difference of the pelvic laxity[12]. In our study the left-right differences of the pelvic inclination angles were significantly larger in the pregnant women with pelvic pain, and we thought that the pregnant women who have pelvic pain would most likely have a tendency to show asymmetric differences. This asymmetric difference was not found in the comparison between the pregnant and non-pregnant women groups. Therefore, left-right differences in the angle might be used as an assessment for pregnant women having pelvic pain.

It is important to maintain the pelvic position to the symmetric position because asymmetric weight bearing might occur when standing with an increased pelvic inclination. Moreover, if pregnant women with an increased inclination walk with the pelvis inclined, the movement would most likely give the non-elevated side of the pelvis a continuous shock, and the activation of the muscles around the pelvis and lumbar spine would probably be asymmetric. Therefore continuous and unbalanced muscle activation would lead to muscle fatigue and disturb efficient contractions to stabilize the SIJ. Since the ability to change the pelvic inclination angle did not differ for the pelvic pain group, pelvic exercises to correct an inclined frontal plane position may be possible and effective in solving the unbalanced contractions of the muscles.

Conclusion

The authors found that another method to distinguish the movement of the SIJ by measuring the inclination angle of the bilateral PSIS. This study showed that 1) the method which we utilized might be useful to determine the pelvic position in the frontal plane, 2) the pelvic position of pregnant women were significantly inclined in standing, but the movements of the pelvis do not change as a result of pregnancy, and 3) the pelvis of the pregnant women with pelvic pain was significantly inclined to the non-elevated side. Further more study will be necessary to improve the method and to develop an effective intervention to focus on pelvic asymmetry.

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