# Comparison of changes in the pelvis and pelvic floor muscle function between normal pregnant women and pregnant women with cervical incompetence

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# Comparison of changes in the pelvis and pelvic floor muscle function between normal pregnant women and pregnant women with cervical incompetence

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**Abstract**

**Aim**: To compare the changes in the pelvis and pelvic floor muscle function in normal pregnant women and pregnant women with cervical incompetence.

**Methods**: The subjects consisted of 14 normal pregnant women and 10 pregnant women with cervical incompetence. Perineal body lengths, intercristal, interspinous and intertrochanteric diameters, and pelvic floor muscle function were measured at 16-19 (stage 1), 24-27 (stage 2), 30-33 weeks of gestation (stage 3) and 36 weeks of gestation onward (stage 4) longitudinally.

**Results**: Perineal body lengths in normal pregnant women significantly increased as the pregnancy progressed ($p < 0.05$), but no significant difference was found in pregnant women with cervical incompetence. There were significant differences at 24-27 weeks of gestation in pelvic floor muscle function, which was lower in pregnant women with cervical incompetence compared to normal pregnant women ($p < 0.05$). However, in both groups, perineal body lengths and pelvic floor muscle function were similar at 36 weeks of gestation onward. The relative values of intercristal, interspinous and intertrochanteric diameters at stage 4 based on stage 1 in normal pregnant women were 1.02, 1.02 and 1.01, respectively, while those in pregnant women with cervical incompetence were 1.02 at all three sites.

**Conclusion**: This study suggested that widening of the pelvis associated with pregnancy is a phenomenon that occurs regardless of the presence or absence of abnormality during the course of the pregnancy. Length of the perineal body increased significantly in normal pregnant women during the course of the pregnancy. We infer that increased perineal body length is the result of the relaxation of pelvic floor muscles and weight of the pregnant uterus. We need discussion about reliability and validity to assess pelvic floor muscle function. Meanwhile, the result from this research could be that in the first trimester the levator ani muscles and pelvic floor muscles of pregnant women with cervical incompetence are already more relaxed than those of normal pregnant women.

**Key words**

cervical incompetence, pelvic floor muscle function, pelvis, perineal body, normal pregnancy

## Introduction

Cervical incompetence refers to cervical dilation and bulging membranes in the absence of uterine contractions at 16 weeks of gestation or later[1]. It is recognized as one of the causes of prematurity in the second trimester, whose incidence is estimated

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to be less than 1%[2]. One third of pregnant women with cervical incompetence are primiparae, and early diagnosis before the onset of clinical symptoms is difficult. Meanwhile, studies have reported that the risk factors for pregnant women with only a history of normal delivery to develop cervical incompetence are a history of curettage, precipitous delivery or prolonged second stage of labor, but the results are inconclusive[3]. Pregnant women with a history of abortion or premature delivery due to cervical incompetence are said to be at high risk of abortion or premature delivery at the same gestational stage during a subsequent pregnancy. Although functional cervical insufficiency is described as one of the causes of cervical incompetence, conclusive evidence has yet to be shown[4-5]. In addition, significant controversy remains regarding the effectiveness of interventions such a cerclage and bed rest in the treatment of cervical incompetence[6-10].

In the event of a normal pregnancy, the pregnant uterus that grows as the pregnancy progresses rests on the pelvic diaphragm. The pelvic floor muscles and ligaments which support and close the pelvic floor are associated with the support of the pregnant uterus. The funnel-shaped pelvic diaphragm constitutes the upper level of the pelvic floor, and the levator ani muscles which constrict the lower end of the rectum and vagina play a particularly important role. The pubocervical ligament, uterosacral ligament and cardinal ligament also play a part in the support. In the last trimester, hormones allow the pelvic floor muscles as well as pelvic ligaments and cartilage to relax in preparation for delivery[11]. However, in the event of cervical incompetence, the anteversion and anteflexion of the pregnant uterus could not kept due to the relaxation of pelvic floor muscles and ligaments during and after the second-trimester, and that the position of the uterine cervix to the axis of the pelvis becomes the same as the state of the third-trimester in normal delivery. As a result, cervical ripening could be promoted.

Due to the complex nature of the pelvic floor muscle, its structure is not well understood and the subject has not been explored for years[12]. Some discussions in relation with delivery progression have recently been made[13-15]. However, the relationship between the changes in the pelvis and pelvic floor muscles and cervical incompetence during pregnancy has not been studied. If there are differences between the changes in the pelvis and pelvic floor muscles among pregnant women with cervical incompetence and normal pregnant women, a basis for recommending pelvic floor muscle training, a non-invasive prevention that strengthens the pelvic diaphragm composed of striated muscles could be explored.

The porpose of this study is to demonstrate the changes in pelvic floor function and pelvic size in normal pregnant women and pregnant women with cervical incompetence.

## Operational Definitions

**Normal pregnant woman**: a pregnant woman who has not been diagnosed with cervical incompetence in a previous pregnancy and who is currently having a normal pregnancy.

**Pregnant woman with cervical incompetence**: a pregnant woman who has been diagnosed with cervical incompetence in a previous pregnancy, or a pregnant woman who has not been previously diagnosed with cervical incompetence but who has been diagnosed with cervical incompetence during the current pregnancy.

## Subjects and Methods

### 1. Subjects (Table 1)

This study was conducted at the four hospitals in Yamanashi prefecture, Japan from April 2008 to August 2009. The subjects consisted of 14 normal pregnant women (6 primiparae and 8 multiparae) and 10 pregnant women with cervical incompetence (1 primipara and 9 multiparae). All data were collected from the 14 normal pregnant women. Meanwhile, with regard to the 10 pregnant women with cervical incompetence, all the data were collected from 6 of them and the date from the rest, only those during stage 2 onward because they were introduced to researchers from medical doctors after 20 weeks of gestation. The mean age of normal pregnant women and pregnant women

Table 1. Characteristics of participants (mean)

| | Normal pregnant women | | | Pregnant women with cervical incompetence | | | |
|---|---|---|---|---|---|---|---|
| | Primipara n=6 | Multiparae n=8 | Total n=14 | Primipara n=1 | (n=6)* | Multiparae n=9 | Total n=10 |
| Age (years) | 31.0 | 30.0 | 30.4 | 27.0 | (31.2) | 33.7 | 33.0 |
| Height (cm) | 158.3 | 161.1 | 159.9 | 151.0 | (154.8) | 156.8 | 156.2 |
| Weight (Kg) | | | | | | | |
| before pregnancy | 48.3 | 56.0 | 52.7 | 45.0 | (48.1) | 50.8 | 50.2 |
| third trimester | 59.3 | 64.4 | 62.2 | 54.0 | (59.3) | 60.7 | 60.2 |
| Baby weight (g) | 3059 | 3308 | 3201 | 2612 | (2983) | 3031 | 2984 |
| Gestational week of measurement (weeks-day) | | | | | | | |
| stage 1 | 18-3 | 18-3 | 18-3 | 16-4 | (17-4) | 17-6 † | 17-4 ‡ |
| stage 2 | 25-6 | 25-6 | 25-6 | 24-4 | (25-1) | 25-5 | 25-4 |
| stage 3 | 31-1 | 31-2 | 31-2 | 32-5 | (31-2) | 31-0 | 31-1 |
| stage 4 | 37-0 | 37-4 | 37-2 | 37-0 | (36-5) | 36-4 | 36-5 |

*6 subjects (1 primipara and 5 multiparae) who were collected all date
† n=3, ‡ n=4

with cervical incompetence was 30 and 33, respectively. Among the pregnant women with cervical incompetence, 7 had a history of cervical incompetence and had a preventive cerclage place at 12-14 weeks of gestation. The remaining 3 who had no history of cervical incompetence were diagnosed with cervical incompetence during measurement for cervical dilation and had a cerclage placed at 19-25 weeks of gestation. All pregnancies ended in full-term delivery.

**2. Methods**

The perineal body , the pelvic floor muscle function, and pelvimetry were measured.

Wish perineal body and pelvimetry measurements performed longitudinally at 16-19 weeks of gestation (stage 1), 24-27 weeks of gestation (stage 2), 30-33 weeks of gestation (stage 3) and 36 weeks of gestation or later (stage 4), both measurements were performed a total of 4 times. Assessment of pelvic floor muscle function was performed a total of 4 times at 16-19, 24-27, 30-33 weeks of gestation and 36 weeks of gestation or later for the normal pregnant women and a total of 3 times except at 16-19 weeks of gestation for those with cervical incompetence, for in the latter cases, the researchers were concerned with the contraction of pelvic floor muscles at stage 1. Longitudinal assessment was performed in both cases.

**1) Measurement of the Perineal Body**

In the mass of fibrous tissue located at the center of the perineum called the perineal body, the levator ani muscles which make up the pelvic diaphragm and the muscles of the urogenital triangle and the anal triangle converge. Because the levator ani extends upward to the pelvic cavity, relaxation of the muscles that converge at the perineal body was believed to be inferable based on the length of the levator ani. The subjects were placed in the lithotomy position, and the distance between the lower end of the vaginal orifice and upper end of the anus was measured. A digital vernier scale (Mitutoyo Corporation) with a range between 0 and 150mm, resolution of 0.1mm and an accuracy of ±0.02mm was used.

**2) Assessment of the Pelvic Floor Muscle Function**

Assessment of the pelvic floor muscle function based on the degree of contraction has been performed in a study on urinary incontinence and uterine prolapse[16]. Some of the reasons include the difficulty to assess a specific pelvic floor muscle and the presence of synkinesis. Assessment was performed using a vaginal cone, perineometer[17-18], digital examination[19-20] and ultrasound[21]. In this study, the changes in pressure on the ischial tuberosity in the sitting position were used as data. The ischial tuberosity supports the weight of the upper body. The levator ani arises from the pubic and obturator membrane, and runs posteromedially to insert into the coccyx and anococcygeal ligament.

Part of the levator ani is the pubovaginalis and puborectalis, which are associated with rectal and vaginal contraction. In other words, contracting the anus and vagina means contracting the levator ani and therefore it was predicted that pressure on the soft tissues on the inner surface of the ischial tuberosity would decrease. A pressure distribution sensor (BIG-MAT2000P3BS, Nitta Corporation) was used. The sensor sheet's electrode members are coated with a special ink and arranged to form a matrix. When pressure is applied to the intersections, the resistance values of the special ink change according to the intensity of the pressure. The changes in resistance values are transmitted to the sensor connector as vertical or lateral variation of current. The present study used a 440mm×480mm sensor sheet with 2,112 sensors. The pregnant women were in a sitting position on the sensor sheet, without back support. The subjects held a position in which the posterior surface of the femur was in contact with the seat and the entire soles touched the ground. First, it was confirmed that the subjects were not wearing tight underwear or clothing. Before measurements, the researcher provided the following instructions and precautions regarding how to contract the pelvic floor muscles: a. Keep the upper body relaxed; b. while keeping the buttocks firmly on the seat, tighten anal and vaginal muscles; c. do not lift the hips or shift the body weight from front to back or side to side. The pregnant women sat on the sensor sheet. Measurement began after 90 seconds, when the values stabilized. Measuring time in the relaxed state lasted 2 seconds. The researcher asked the women to tighten their anal and vaginal muscles. Measuring time in this state lasted 14 seconds. The women then returned to the relaxed state for another 20 seconds. The sensor was set to measure pressure every 0.1 second, which means 200 readings (No.1－No.200) were obtained during a period of 20 seconds. The pressure measuring range was set to cover a 5-centimeter square section on the right and left ischial tuberosities, and the top pressures were used as data. At the same time, weight on the contact surface of the sensor sheet was also measured to determine if the changes in pressure are due to weight shift from one buttock to the other. A list was created with the right and left pressure data obtained from the 200 readings, and using No.1 as the reference pressure the mean of decompression rates for both the right and left were calculated.

**3) Pelvimetry**

The pelvimeter (scale: 0 to 450mm, precision: 1mm) in Martin's anthropometer kit was used. The shape is similar to the Martin pelvimeter (scale: 320mm, precision: 1cm) used in obstetrics. The intercristal, interspinous and intertrochanteric diameters were measured in a natural upright position.

**4) Date analysis**

The perineal body lengths of the normal pregnant women and women with cervical incompetence at each stage, differences in the intercristal, interspinous and intertrochanteric diameters of the pelvis within each group and between the groups, and decompression rates during sustained maximal contraction of the pelvic floor muscles were compared. To compare differences between three or more dependent groups, the Friedman's $\chi^2$ r-test was used. To compare differences between two groups within these groups the Wilcoxon t-test with Bonferroni correction was used. To compare differences between two independent groups the Mann-Whitney U-test was used.

**5) Ethical Considerations**

The participants were informed in writing and verbally about the purpose, method, and significance of the study. They were told that participation was voluntary, that they were free to withdraw at any time and that their withdrawal would have no consequences. They were also told that full confidentiality was guaranteed. An informed consent was obtained from all participants. The measuring times for each participant were kept minimal to minimize burden. This study was approved by the medical ethics committee of Kanazawa University (permission no; Health-127) as well as by the ethics committee of each of the participating research facilities.

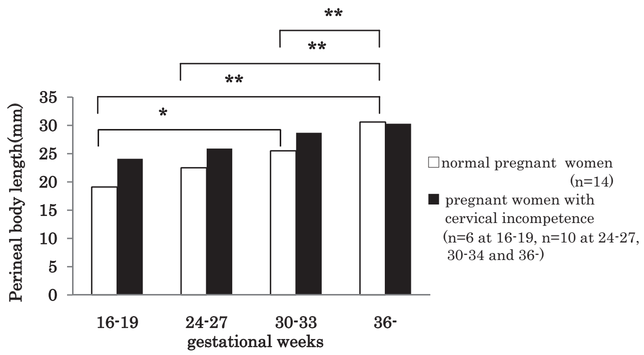


Figure 1. Perineal body length.
*P＜0.05 and **P＜0.01 were considered significant.

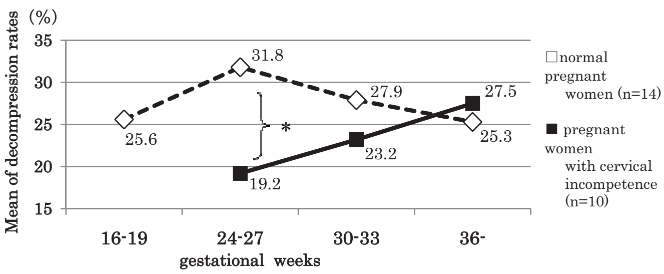


Figure 2. Mean of decompression rates during sustained maximal contraction of pelvic floormuscles
＊P＜0.05 was considered significant.

## Results

### 1. Perineal Body Length (Fig. 1)

There were significant differences in perineal body lengths of normal pregnant women ($p<0.05$). More specifically, there were significant differences between stages 1 and 3 ($p<0.05$), stages 1 and 4 ($p<0.01$), stages 2 and 4 ($p<0.01$) and stages 3 and 4 ($p<0.01$). However, there were no significant differences between primiparae and multiparae. Meanwhile, there were no significant differences in perineal body lengths between each stage in pregnant women with cervical incompetence. In addition, there were no significant differences in perineal body lengths at the same stages between normal pregnant women and pregnant women with cervical incompetence, and at stage 4 the perineal body lengths between normal pregnant women and pregnant women with cervical incompetence were nearly equal.

### 2. Mean of Decompression Rates During Sustained Maximal Contraction of the Pelvic Floor Muscles (Fig. 2)

There were no significant differences in the mean values of decompression rates during sustained maximal contraction of the pelvic floor muscles in normal pregnant women between stages 1, 2, 3 and 4, which were 25.6±18.7%, 31.8±13.1%, 27.9±21.2% and 25.3±18.5%, respectively. There were also no significant differences in pregnant women with cervical incompetence between stages 2, 3 and 4, whose mean values were 19.2 ±14.3%, 23.2±10.5% and 27.5±13.7%, respectively. However, although pregnant women with cervical incompetence showed significantly lower mean of decompression rates during sustained maximal contraction of the pelvic floor muscles at stage 2 ($p<0.05$), by stage 4, the rates were nearly equal between the two groups.

### 3. Intercristal, Interspinous and Intertrochanteric Diameters

Table 2 shows the measured values of intercristal, interspinous and intertrochanteric diameters at each stage in normal pregnant women and pregnant women with cervical incompetence. No significant difference was found at each measurement stage between normal pregnant women and pregnant women with cervical incompetence. In both groups, the diameters at stage 4 were larger

Table 2. Intercristal, Interspoinous, and Intertrochanteric Diameters

| | Normal pregnant women (n=14) | | | | Pregnant women with cervical incompetence (n=6) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Gestational weeks | | | Relative values | Gestational weeks | | | Relative values | |
| | 16-19(a) | 36-(b) | (b)-(a) | | 16-19(a) | 36-(b) | (b)-(a) | | |
| | (cm) | (cm) | (cm) | | (cm) | (cm) | (cm) | | |
| Intercristal diameter | 26.8 | 27.5 | 0.63 | 1.02 | 26.3 | 27.0 | 0.68 | 1.02 | n.s. |
| Interspinous diameter | 23.4 | 23.8 | 0.36 | 1.02 | 23.2 | 23.7 | 0.23 | 1.02 | n.s. |
| Intertrochanteric diametr | 30.5 | 30.7 | 0.17 | 1.01 | 28.8 | 29.3 | 0.42 | 1.02 | n.s. |

Mann-whitney U-test

than at stage 1. Moreover, based on the diameters at stage 1 of the 14 normal pregnant women and 6 pregnant women with cervical incompetence who were able to undergo measurements at all 4 times during pregnancy, the mean relative values of intercristal and interspinous diameters at stage 4 were all 1.02 and those of intertrochanteric diameters were 1.01 and 1.02.

## Discussion

Comparisons of pelvic intercristal, interspinous and intertrochanteric diameters in normal pregnant women and pregnant women with cervical incompetence at 16-19 weeks of gestation and 36 weeks of gestation or later revealed that the mean relative values in normal pregnant women were 1.02, 1.02 and 1.01, respectively, while those of pregnant women with cervical incompetence were all 1.02, showing similar changes in both groups. During pregnancy, hormones allow the cartilage of the pubic symphysis and ligaments of the sacro-iliac joint to become slightly flexible, causing the birth canal to dilate during delivery. In particular, relaxation of the pubic symphysis begins in the first trimester and gradually progresses in the third trimester[22-23]. It has also been noted that during pregnancy, such relaxation causes changes in posture, which could result in changes in its shape[24]. The fact that the softening of the pelvic cartilage and ligaments occurs before delivery is consistent with previous studies. However, there were no prior studies numerically reporting the widening of the pelvis. Results of the present study suggested that widening of the pelvis associated with pregnancy is a phenomenon that occurs regardless of the presence or absence of abnormality during the course of the pregnancy.

We then performed measurements of perineal body lengths. Length of the perineal body increased significantly in normal pregnant women during the course of the pregnancy. Length of the perineal body also increased in pregnant women with cervical incompetence but there were no significant differences. In a study conducted by O'Boyle et al.[25], cross-sectional measurements of the perineal body in normal pregnant women revealed that compared to the first trimester, the lengths increased by 0.85mm on average by the third trimester. The study reported that this is possibly as a result of alterations in collagen that may occur because of the hormonal influences of pregnancy and that it is a protective adaptation against anal sphincter injury. The present study consists of an unprecedented longitudinal study. Comparisons of perineal body lengths in normal pregnant women between 16-19 weeks of gestation and 36 weeks of gestation or later showed increases of more than 1cm. Despite the small number of subjects who participated in the present study, we were able to report with conviction that increased perineal body length is a normal phenomenon that occurs during pregnancy. The perineal body is where the levator ani muscles and other pelvic floor muscles, which play an important role in supporting the pregnant uterus, gather. It is pulled upward into the pelvic cavity by these muscles. Therefore, we infer that increased perineal body length is the result of the relaxation of pelvic floor muscles and weight of the pregnant uterus. However, while perineal body length increased in pregnant women with cervical incompetence, no significant differences were seen. Although the reason is uncertain, it could be that in the first trimester the levator ani muscles and pelvic floor muscles of pregnant women with cervical incompetence are already more relaxed than those of normal pregnant women. This could explain the fact that their perineal body length was 5mm longer than that of normal pregnant women at 16-19 weeks of gestation.

There were no significant differences in the mean of decompression rates during sustained maximal contraction of the pelvic floor muscles in normal pregnant women, which was performed to assess pelvic floor muscle function. This is interpreted as indicating that in normal pregnant women, pelvic floor muscles relax during the course of the pregnancy but that the force of contraction is maintained. In the third trimester, the pelvic viscera descend due to relaxation of the levator ani muscles[26]. Dietz et al.[27] also indicate that the bearing capacity of the pelvic viscera by the levator ani muscles may decrease but suggest that the force of contraction is maintained. Meanwhile the mean of decompression rates during sustained maximal contraction of the pelvic floor muscles in pregnant women with cervical incompetence were lowest at 24-27 weeks of gestation, showing clear differences with the rates in normal pregnant women. These rates later increased. Although some kind of difference must exist in the state of the pelvic floor muscles during the second trimester between normal pregnant women and pregnant women with cervical incompetence, we still do not have a clear explanation for it. Further studies are necessary using more subjects.

Meanwhile, one intriguing point is that both normal pregnant women and pregnant women with cervical incompetence showed similar values in perineal body lengths and decompression rates during sustained maximal contraction of the pelvic floor muscles at 36 weeks of gestation or later. The reasons are unclear, but this could indicate that at 36 weeks of gestation or later, there are no significant differences in the state of the pelvic floor muscles between normal pregnant women and pregnant women with cervical incompetence. In addition, perineal body lengths may have increased to a maximum extent due to relaxation of pelvic floor muscles and weight of the pregnant uterus.

Furthermore, we describe the possibility of pelvic floor muscle training as a prevention of cervical incompetence. Results of the present study suggested differences in pelvic floor muscle function and the relaxation of these muscles in the second trimester between normal pregnant women and pregnant women with cervical incompetence. However, the relationship between these results and development of cervical incompetence is unclear. Therefore, in order to further pursue this issue, data of non-pregnant women with a history of cervical incompetence and those of non-pregnant women who had a normal delivery are necessary.

Finally, regarding the research method we adopted in the present study, although assessment of the pelvic floor muscle function has traditionally been performed using the force of contraction of the muscles and in some cases, ultrasound echo or X-ray computed tomography[28-29], because not only is the assessment of the pelvic floor muscle function difficult in nature[30] but roughly 30% of people are not capable of tightening anal and vaginal muscles, the data may not be accurate[31-32]. We need discussion about reliability and validity to assess pelvic floor muscle function. Meanwhile, the result from this research could be that in the first trimester the levator ani muscles and pelvic floor muscles of pregnant women with cervical incompetence are already more relaxed than those of normal pregnant women.

## Conclusions

The results of comparison of changes in the pelvic and pelvic floor muscle function between normal pregnant women and pregnant women with cervical incompetence in the present study are as following:

1. There were significant differences in perineal body lengths of normal pregnant women between stages 1 and 3 ($p<0.05$), stages 1 and 4 ($p<0.01$), stages 2 and 4 ($p<0.01$) and stages 3 and 4 ($p<0.01$). However, there were no significant differences between primiparae and multiparae and each stage in pregnant women with cervical incompetence.
2. There were no significant differences in the mean values of decompression rates during sustained maximal contraction of the pelvic floor muscles in normal pregnant women and pregnant women with cervical incompetence. However, although pregnant women with cervical incompetence showed significantly lower decompression rates during sustained maximal contraction of the pelvic floor muscles at stage 2 ($p<0.05$).
3. Based on the diameters at stage 1 of normal pregnant women and pregnant women with cervical incompetence, the mean relative values of intercristal and interspinous diameters at stage 4 were all 1.02 and those of intertrochanteric diameters were 1.01 and 1.02.

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# 正常妊婦と子宮頸管無力症妊婦の骨盤と骨盤底筋機能の変化の比較

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## 要　　旨

**【目的】**正常妊婦と子宮頸管無力症妊婦の妊娠中の骨盤と骨盤底筋機能の変化を比較することである。**【方法】**対象者は14人の正常妊婦と10人の子宮頸管無力症妊婦であった。会陰腱中心の長さと骨盤の稜間径、棘間径、大転子間径の測定、さらには骨盤底筋機能の評価のために、座位での骨盤底筋収縮時の坐骨結節への圧の変化を測定した。測定は妊娠16-19週（１期）、妊娠24－27週（２期）、妊娠30-33週（３期）、妊娠36週以降（４期）と４回縦断的に実施した。**【結果】**正常妊婦の会陰腱中心は、妊娠進行に伴って有意に伸展した（$p<0.05$）が、子宮頸管無力症妊婦では差がなかった。骨盤底筋機能評価である骨盤底筋収縮時圧の最大減少率の平均は、妊娠24～27週において子宮頸管無力症妊婦が正常妊婦のより有意に低かった($p<0.05$)。しかし妊娠36週以降の両者の会陰腱中心の長さと骨盤底筋機能の測定値は同程度となった。骨盤稜間径、棘間径、大転子間径の１期を基準とした４期の相対値は、正常妊婦が1.02・1.02・1.01、子宮頸管無力症妊婦は３か所すべて1.02であった。**【結論】**妊娠にともなう骨盤の広がりは、妊娠経過の異常の有無に関係なく起こる現象であることが示唆された。また、正常妊婦の会陰腱中心は妊娠経過に伴って有意に伸展した。これは、骨盤底筋の弛緩とそれに妊娠子宮の重みが加わった結果だと推測する。骨盤底筋機能評価方法には信頼性・妥当性の課題があるが、子宮頸管無力症妊婦においては、正常妊婦と比べ肛門挙筋や他の筋が妊娠初期から弛緩していることが推察される結果を得た。