

## AOGS MAIN RESEARCH ARTICLE

# Spinal curvature and characteristics of postural change in pregnant women

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Pregnancy, posture, spinal curvature, complaints, standing

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## Conflict of interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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## Introduction

Pregnant women may experience many physiological and anatomical changes, particularly postural changes, in their body (1) and often report symptoms of low back pain (2–4), pelvic girdle pain (5–7), leg problems (8) and urinary incontinence (9). More than two-thirds of pregnant women experience back pain and almost one-fifth experience pelvic pain (6), and approximately one-third have urinary incontinence (9). Complaints during pregnancy can continue postpartum. Postural changes in pregnant women are a recognized cause of low back pain and pelvic girdle pain; however, little research has been conducted on these changes.

The influence of specific hormones during pregnancy and postural change due to the increased and altered mass distribution in the trunk are thought to be factors underlying these

## Abstract

**Objective.** Pregnant women often report complaints due to physiological and postural changes. Postural changes during pregnancy may cause low back pain and pelvic girdle pain. This study aimed to compare the characteristics of postural changes in pregnant compared with non-pregnant women. **Design.** Prospective case–control study. **Setting.** Pregnancy care center. **Population.** Fifteen women at 17–34 weeks pregnancy comprised the study group, while 10 non-pregnant female volunteers comprised the control group. **Methods.** Standing posture was evaluated in the sagittal plane with static digital pictures. Two angles were measured by image analysis software: (1) between the trunk and pelvis; and (2) between the trunk and lower extremity. Spinal curvature was measured with Spinal Mouse<sup>®</sup> to calculate the means of sacral inclination, thoracic and lumbar curvature and inclination. **Main outcome measures.** The principal components were calculated until eigenvalues surpassed 1. **Results.** Three distinct factors with eigenvalues of 1.00–2.49 were identified, consistent with lumbosacral spinal curvature and inclination, thoracic spine curvature, and inclination of the body. These factors accounted for 77.2% of the total variance in posture variables. Eleven pregnant women showed postural characteristics of lumbar kyphosis and sacral posterior inclination. Body inclination showed a variety of patterns compared with those in healthy women. **Conclusions.** Spinal curvature demonstrated a tendency for lumbar kyphosis in pregnant women. Pregnancy may cause changes in spinal curvature and posture, which may in turn lead to relevant symptoms. Our data provide a basis for investigating the effects of spinal curvature and postural changes on symptoms during pregnancy.

complaints in pregnancy (10,11). A relation between postural changes and complaints such as low back pain, pelvic girdle pain and urinary incontinence has been reported in healthy people. Especially in the second and third trimester, many pregnant women seem to demonstrate a sway-back posture, in which the upper trunk is displaced posterior the lower body from the pelvis (12,13), as also observed in patients with low back and pelvic girdle pain.

## Key Message

This study demonstrated that pregnant women showed a tendency for lumbar kyphosis, and it could provide a basis for investigating the effects of spinal curvature and postural changes on symptoms during pregnancy.

The increased and altered mass distribution of the trunk can shift the center of gravity anteriorly and induce lumbar lordosis with anterior tilt of the pelvis. Postural changes or adjustments are necessary to maintain balance and stability (10,11). Anatomical changes that occur during pregnancy may be one factor underlying complaints such as low back pain. However, it is unclear whether all pregnant women develop sway-back posture, whether pregnant women without any complaints show any postural changes, and whether any postures are associated with absence of complaints.

Previous studies on posture of pregnant women have reported different results. In general, lumbar lordosis and thoracic kyphosis appear to increase during pregnancy (14). Moore et al. reported a flatter lumbar curvature in pregnant women during standing as pregnancy progressed (15). Gilleard et al. have also reported a tendency in some pregnant women for a flatter thoracolumbar spinal curvature during sitting as pregnancy progressed (16). Franklin et al. suggested that in the standing position, lumbar lordosis and sagittal pelvic tilt increased, and the head position becomes more posterior as women go from the first trimester to the last trimester of pregnancy, but observed no relation between postural change and back pain (13). Evidence of a relation between postural changes and complaints such as low back pain and urinary incontinence has not yet been reported.

Measuring spinal curvature is one method of postural assessment. Spinal curvature and posture and the complaints of pregnant women may be related; however, few studies have addressed the evaluation of posture and spinal curvature. One reason for the lack of consistency between studies of postural change in pregnant women is the difficulty in measuring and evaluating posture. Radiographic assessment of spinal curvature is common, but risks exposing pregnant women to radiation. To avoid the risk of radiation exposure, we evaluated spinal curvature using a skin-surface device, Spinal Mouse® (Index Ltd, Tokyo, Japan), which demonstrated good intra-day and interclass reliability for the measurement of standing sacral angle, lumbar lordosis and thoracic kyphosis (17). We also used digital photographs to assess posture during pregnancy, which can provide reproducible and objective data for analysis.

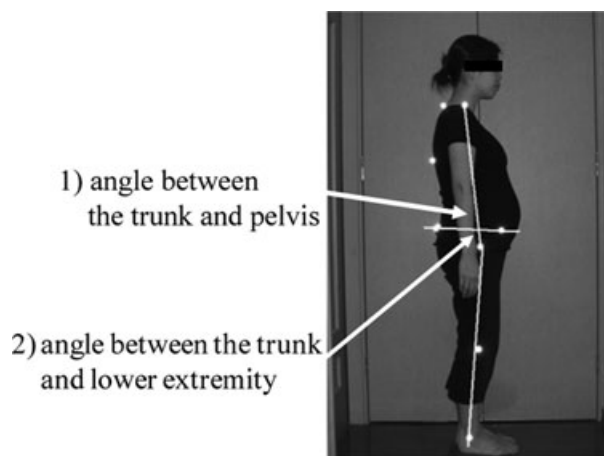
A thorough understanding of the impact of postural changes is necessary for the development and implementation of beneficial exercises to improve symptoms. The purpose of this study was to demonstrate the characteristics of postural change in pregnant women compared with those in age-matched non-pregnant women. We hypothesized that pregnant women would demonstrate lumbar lordosis and anterior pelvic tilt compared with healthy non-pregnant women and that those characteristics of spinal curvature would lead to sway-back posture.

## Material and methods

We studied 15 healthy pregnant women, 17–34 weeks into pregnancy, who had been assessed by an obstetrician prior to participation. Ten non-pregnant healthy female volunteers comprised the control group. Inclusion criteria were age from 18 to 40 years and gestational period from 16 to 35 weeks. The Hiroshima International University, Human Research Ethics Committee approved all procedures. All participants provided written informed consent prior to enrollment.

Static digital photographs were taken to evaluate standing posture in the sagittal plane. Reflective surface markers were placed on the acromion, anterior superior iliac spine, posterior superior iliac spine, greater trochanter, lateral knee joint space and lateral malleolus on the right side. The images were transferred to a computer, and the following two angles were measured by image analysis software (ImageJ 1.42; National Institutes of Health, Bethesda, MD, USA): (1) the angle between the trunk and pelvis and; and (2) the angle between the trunk and lower extremity. The angle between the trunk and pelvis was defined as that formed by the line from the acromion to the greater trochanter and the line from the anterior superior iliac spine to the posterior superior iliac spine. The angle between the trunk and lower extremity was defined as that formed by the line from the acromion to the greater trochanter and the line from the greater trochanter to the lateral malleolus (Figure 1).

Spinal curvature was measured from the cervical spine to the sacrum using a non-invasive skin surface measurement



**Figure 1.** Two angles were measured from static digital pictures, as shown: (1) the angle between the trunk and pelvis was defined as that formed by the line from the acromion to the greater trochanter and the line from the anterior superior iliac spine to the posterior superior iliac spine; and (2) the angle between the trunk and lower extremity was defined as that formed by the line from the acromion to the greater trochanter and the line from the greater trochanter to the lateral malleolus.

device, Spinal Mouse<sup>®</sup>, while the women were standing. The mean values for sacral inclination, thoracic kyphosis, lumbar lordosis and inclination were calculated.

### Statistical analysis

The principal component analysis was calculated using SPSS for Windows 15.0J (SPSS Japan Inc., Tokyo, Japan). The variables included the two angles determined by static picture analysis and the mean sacral inclination, thoracic kyphosis, lumbar lordosis and inclination values measured by Spinal Mouse<sup>®</sup>. Factor analysis is a type of multivariate analysis that effectively clarifies the relations among variables and groups them to describe a reduced number of independent factors. The strength of the relation among variables for each factor is the factor loading and represents the correlation between the variables and the factor. Meaningful factors were defined as those with the calculated eigenvalues  $\geq 1$ . We analysed the postural characteristics of all participants by plotting all data on co-ordinate axes to classify postural groups.

Student's unpaired *t*-test was used to compare the differences of age, height and body weight between pregnant and non-pregnant healthy women. A value of  $p < 0.05$  was regarded as significant.

## Results

The participating women included six primiparous and nine parous women. Mean gestational age was 24.5 weeks (range, 17–34 weeks). The mean age, height and body weight of the women are shown in Table 1. No significant differences in age ( $p = 0.94$ ), height ( $p = 0.09$ ) or body weight ( $p = 0.59$ ) were observed between pregnant and non-pregnant women.

Eigenvalues, contribution ratios and cumulative contribution ratios were calculated by principal component analysis and are shown in Tables 2 and 3. Three distinct factors with eigenvalues between 1.00 and 2.49 were identified; the first factor represented lumbosacral spinal curvature and lumbosacral spinal inclination, the second factor thoracic spine curvature and the third factor inclination of the body. These factors accounted for 77.18% of the total variance in posture variables.

Relations between principal component scores and posture evaluation data were investigated. The characteristic posture of each participant was classified according to each com-

**Table 1.** Physical characteristics [means (SD)] of each group.

Measurement	Pregnant women ( <i>n</i> = 15)	Healthy women ( <i>n</i> = 10)
Age (years)	31.1 (3.6)	32.3 (3.7)
Height (cm)	156.53 (4.87)	158.40 (7.72)
Body weight (kg)	54.27 (7.05)	50.30 (6.11)

**Table 2.** Principal component analysis.

	First principal component	Second principal component	Third principal component
Lumbar lordosis	-0.94	0.21	-0.06
Sacral inclination	0.91	0.08	-0.12
Angle between the trunk and pelvis	0.44	-0.36	-0.23
Inclination	0.13	0.84	0.28
Thoracic kyphosis	0.57	-0.14	0.73
Angle between the trunk and lower extremity	0.50	0.50	-0.57

ponent score, as shown in Figure 1. Unlike the pattern observed in healthy non-pregnant women, 11 pregnant women demonstrated postural characteristics of reduced lumbar lordosis and sacral posterior inclination (Figure 2A) and nine demonstrated slight posterior inclination (Figure 2B). The thoracic curvature of pregnant women demonstrated several patterns similar to that of healthy non-pregnant women (Figure 2C).

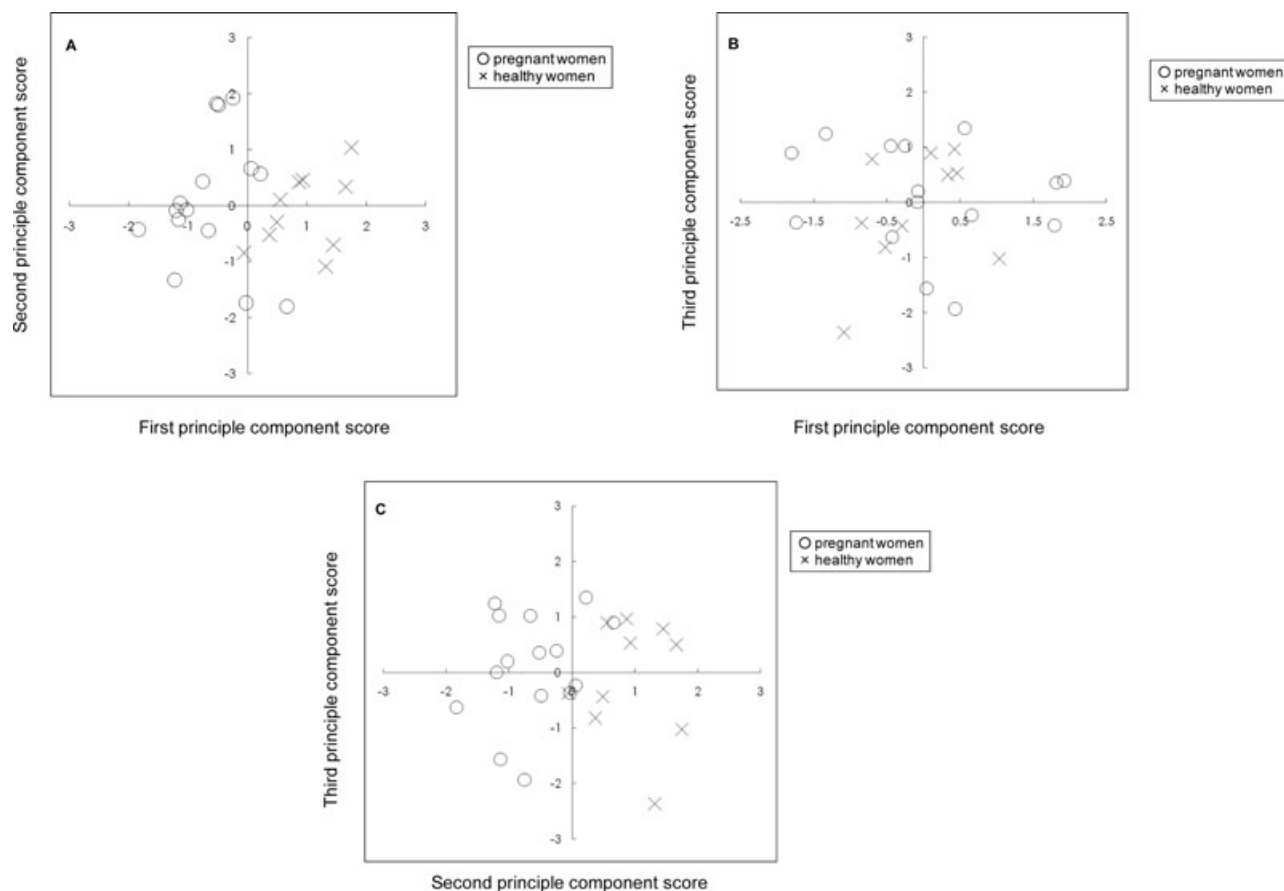
## Discussion

The purpose of this study was to demonstrate the characteristics of postural change in pregnant women compared with non-pregnant women. In the present study, pregnant women were shown to have a flat lumbar spinal curvature or decreased lumbar lordosis and sacral posterior inclination. The pregnant women also stood with a slightly posterior inclination. In this study, pregnant women showed a tendency for decreasing spinal curvature, possibly causing the angles of lumbar lordosis and sacral inclination to decrease. Spinal deformation may also occur in pregnant women (18). These results were not consistent with the hypothesis that pregnant women demonstrate lumbar lordosis and anterior pelvic tilt compared with healthy non-pregnant women.

The first principal components were found to reflect lumbosacral curvature, the second principal components inclination of the body and the third principal components thoracic curvature. The use of principal component analysis to

**Table 3.** Principal component analysis.

	First principal component	Second principal component	Third principal component
Eigenvalue	2.49	1.15	1.00
Contribution ratio (%)	41.42	19.13	16.63
Cumulative contribution ratio (%)	41.42	60.55	77.18



**Figure 2.** Characteristics of the principal component score. (a) First principal component score vs. second principal component score. (b) First principal component score vs. third principal component score. (c) Second principal component score vs. third principal component score.

indicate the characteristics of posture in pregnant women ensured that these factors, from many variables that we measured in this study, were related to posture. The postures of the pregnant women differed from those of non-pregnant women, and these differences might have occurred during pregnancy. Postural changes in pregnancy are influenced by an individual's posture when not pregnant, and it is unclear whether these results indicate only the influence of pregnancy. Our results suggest that pregnant women do have a characteristic posture, with lumbosacral curvature reflecting kyphosis.

Pregnant women may demonstrate increased lumbar and cervical lordosis to compensate for the movement of their center of gravity and posterior shift in body weight (18). Differing opinions exist concerning pelvic inclination and lumbar lordosis in pregnant women (13–16), which may be the result of differences in measurement tools or term of pregnancy in those studies. The direct measurement of spinal curvature, as performed here, may be particularly appropriate for evaluating the posture in pregnant women. Postural

analysis using digital photographs and Spinal Mouse<sup>®</sup> could easily be applied to clinical settings with little physical stress for the pregnant women, and thus provide a useful and easy postural assessment method.

Although a relation between posture and complaints such as back pain during pregnancy has been shown, the present study did not clarify this. Such complaints may result from increased levels of relaxin loosening pelvic ligaments during pregnancy (8,19). Biomechanical factors have also been suggested to play a larger role than hormonal influences on pregnancy complaints (8). Pregnant women with anterior translation of their center of mass have been shown to lack positional adjustment of lumbar lordosis, and the force of gravity, when more distant from the hip, generates a larger hip moment and an unstable upper body (14). Many pregnant women demonstrate a sway-back posture, whereby the upper trunk is displaced posterior to the lower body. Sway-back posture increases the tone of back muscles to maintain thoracic kyphosis, causing the center of gravity to shift further backward, and increases the tone of head and neck

muscles, causing the head to shift forward to compensate for the change in center of gravity and prevent falling (18). Pregnancy-related changes in trunk motion during a walking task may indicate altered musculoskeletal loads with potential for injury or pain, and pregnancy was shown to induce significant changes in postural control when women stood with a reduced support base (12). Progression of symptoms is seen especially in the third trimester as the center of gravity changes due to weight gain (20). Pregnancy may result in strain symptoms in the lumbosacral region and pelvis, with variable pain intensifying in various static positions (21).

This study has some limitations. The postural data were obtained only in the sagittal plane, and data from the frontal and horizontal planes should be measured to reveal additional postural characteristics of pregnant women. Additionally, the number of women studied may not have been sufficient to reveal all postural characteristics of pregnant women.

The results of this study still demonstrated some unique structural features of spinal curvature and the characteristic posture of pregnant women, and indicated a possible relation between posture and pregnancy complaints. Many studies concerning the treatment of pregnancy-related complaints have been reported by physical therapists (9, 21–24), but the treatments are limited by the unknown etiology of complaints. Additional research is needed to investigate the relation between posture and pregnancy-related complaints further and to identify strategies for prevention and treatment.

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