



Postural Changes during First Pregnancy

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Authors' contributions

This work was carried out in collaboration between all authors. Author AR designed and supervised the whole study, wrote the protocol, revised the manuscript. Author SK wrote the protocol, carried out the work in hospital, managed the experimental process and wrote the first draft of the manuscript. Authors MG and SSN helped in designing the work and revising the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The precise changes in postures of each part of the spine of primigravid women are still ambiguous. This study aimed to find out the spinal curvature and pelvic tilt changes during the first pregnancy.

Study Design: Observational longitudinal study (Cohort study).

Place and Duration of Study: The study was conducted at a hospital clinic in Iran, between April 2014 and December 2014.

Methodology: Thirty primigravid women at the first, second and third trimesters of pregnancy were recruited in this cohort study and their lumbar and thoracic curves changes and pelvic inclination angles were studied and compared with 18 age-BMI matched non-pregnant women. The curves were measured by use of a flexible ruler and the pelvic inclination angle was measured by a pelvic inclinometer device. Before starting the main study, the reliability and repeatability of the measuring tools were confirmed in this study (ICC>0.87). A one-way ANOVA and independent t-

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test were used for statistical analysis.

Results: Marked increased curvature and inclination angles were revealed as pregnancy advanced ($P < 0.05$). The lumbar lordosis significantly increased when the first trimester was compared with the second and third ones. The thoracic curvature showed significantly increased curvature between the first and third and between the second and third trimesters. None of the lumbar or thoracic curve showed significantly difference between the control group and pregnant women during the first trimester of pregnancy. Although ten weeks pregnancy increased lumbar lordosis and thoracic kyphosis (4.2%, 8%, respectively), but it was not significant when compared with no pregnant women. The pelvic inclination angle showed to be more sensitive than spinal curvatures as it showed significant increase within all trimesters and when compared to the control group. Interestingly, it increased nearly 2.5 times more at the end of pregnancy (236%).

Conclusion: The present study showed a significant increase in most variables that became higher as the months of pregnancy increased. The results might help clinicians for prescribing suitable exercises or spinal orthoses during pregnancy. More research is recommended in this area in women intending to get pregnant.

Keywords: Primigravid women; spinal curvatures; pelvic tilt; flexible ruler; pelvic inclinometer.

1. INTRODUCTION

Pregnancy as a physiologic phenomenon characterizes via simultaneous enlargement of both fetus and mother [1]. The fetal enlargement results in changes in mother's center of mass and hence changes the weight distribution pattern of mother [2,3]. This means that the continuous postural changes occurring during pregnancy is counter balanced with compensatory changes in spinal column [2]. The pelvic tilt and lumbar and thoracic curvature changes are the most common modifications in pregnancy, which are still controversial in literature [2,4,5]. While some research reported increased lumbar, thoracic and pelvic tilt angles [1], others stated a decreased lumbar angle [6,7] during pregnancy. Some researchers have also reported no significant changes in pelvic tilt [2,5], thoracic [5,7-8] and lumbar curvatures [9] during pregnancy. Low back pain due to postural changes, is the second common neurological disorder seen in 50-90% of pregnant women in the USA [1,10-12]. Ee et al. [13] reported an increased rate of post-partum back pain in pregnant women who had back pain during pregnancy. Wang et al. [11] emphasized a relationship between back pain and insomnia and disturbance in their quality of life. This might be due to the significant role of the pelvis and spinal curvatures in both static and dynamic postures in human to reduce its energy expenditure [4,14-15]. Very little studies have closely monitored any postural changes in pregnant women [5]. Each postural change may cause compensatory alterations in the body, particularly in lower extremities, to keep the line of gravity as close as its normal condition [16]. In

addition, postural changes may increase the risk of fall in pregnant women [1]. An interesting study in the USA shows the rate of falling in pregnant women is as high as elderly people with age 65 years old [15]. Vullo et al. [17] found the hip and then knee joints as the most vulnerable joints experiencing pain in pregnancy. Another study reported that 88% of pregnant women complained of neurological symptoms in lower limbs during pregnancy and 42% from general pain after the delivery [18]. Obviously returning to the pre-pregnancy status is not possible in a short time following delivery [19] and any postural changes may last for months 8, which are detrimental for human musculo-skeletal system [4]. Bullock-Saxton reported increased spinal curvatures for at least two months following the delivery [19]. Since physiotherapists prescribe remedial exercises for pregnant women with pain at their thoracic and lumbar areas to help to return their faulty postures to their normal condition fast, it is necessary to find out the trends of spinal curvatures during pregnancy to choose the best intervention for their postural corrections [20]. The current study aimed to examine the lumbar and thoracic curvatures and pelvic tilt changes during trimesters of pregnancy in primigravid women.

2. MATERIALS AND METHODS

2.1 Pilot Study

A pilot study was conducted on six pregnant and six non-pregnant women, two in one day and one in a week later. It showed an excellent ($> 80\%$) ICC and convinced the researchers that the tools

used in this study were reliable enough to continue the test with more subjects.

2.2 Main Study

2.2.1 Study population

The current study was carried out when the Shahid Beheshti Medical University's Ethical Committee approved the test. Based upon the inclusion and exclusion criteria, thirty pregnant women with average of age 25.4 ± 0.7 years old, height 160.8 ± 0.9 Cm and BMI 23.8 ± 0.7 kg/m², at their 10th weeks of pregnancy were recruited. As control group, eighteen nulliparous women were selected and matched with them in terms of age, sex, BMI and the level of physical activities. The pregnant group was assessed at 10th, 21st and 32nd weeks (2.5, 5 and 8 months) of pregnancy as representative of the first, second and third trimesters of pregnancy. The control group was only tested at weeks 10th and 32nd (at the beginning and end of the study). Based on the inclusion criteria, the age of subjects should be between 18 and 35 years old, being primigravida (having no pregnancy or abortion before), no history of lower limb fractures, diabetes or other neuropathies, no alignment or musculo-skeletal deformities on their spine and lower extremities with no history of surgery for spine or lower extremities. The exclusion criteria were having a high risk pregnancy (based on her gynecologist's advice), acute trauma to their spine and lower extremities and pregnancy with twins or more babies.

2.2.2 Procedures

Firstly, both the subjects and their husbands completed the consent forms and were informed about the details of the study. They were also informed that they can depart the study whenever with any reasons and this will not affect on their treatment status in the hospital. The essential demographic information was gathered via interview with subjects and filling the related forms and questionnaires. In addition, the researcher measured their visual analog scale (VAS), spinal curvatures and pelvic inclination angles. The main test was carried out in two steps: Firstly, a flexible ruler (Kearing Model) was used to measure the subjects' thoracic and lumbar curvatures (Fig. 1). The validity and reliability of the ruler has already been reported by Hart et al. (ICC=0.97), Walker et al. (ICC=0.90), and Nourbakhsh et al. (ICC=0.88) for lumbar lordosis; and by Teixeira &

Carvalho (ICC=0.90 & 0.97) for thoracic curvature [21-24]. In this test, while the subject stood free and comfortable with her knees extended and arms adducted to the body, the examiner marked the spinous processes of C7, T12 and S2 vertebrae (Youdas Method) [21,25,26]. To find out the related bony prominence, the Hoppenfeld & Magee's method was used [27,28]. Based on this method, the 12th ribs were touched by the examiner's thumbs on both sides of the subject's back and were connected to each other by a virtual line. The point on the spine that this line crosses was marked as the spinous process of T12. Then, both posterior superior iliac spine (PSIS) points were found on the sacrum and were connected to each other by a virtual line too. This line passed the spinous process of S2. The curves between C7 and T12 were assumed as the thoracic curvature and between T12 and S2 were assumed as the lumbar curvature. When the points were found, the flexible ruler was placed on the subjects' spinal column and pressed to form curves on it. Then, the ruler was removed and positioned on an A3 paper to sketch the curves on the paper. The following standard formula was used to calculate the thoracic and lumbar curvature angles:

$$\theta = 4 \left[\text{Arctg} \left(\frac{2H}{L} \right) \right]$$

Where, θ is the angle of the curve to be found; L the length between the beginning and the end of the curve; and H as the vertical length between L line and the apex of the curve [21,26].

At the second step, a pelvic inclinometer was used to measure the anterior/posterior inclination of the pelvis of the subjects (Fig. 2). An inclinometer has a 23 Cm length base and two 15 Cm arms in each side that freely move 360 degrees in horizontal plane. The ends of the arms are placed on the bony landmarks. A goniometer is placed on the base of the inclinometer with a plumb line hanging from it. When the arms are placed on right points of the body, the angle between this line and the point of 90 degree on the goniometer shows the pelvic inclination angle. The intra-tester and inter-tester reliability of this tool has already been reported as very excellent (98% and 93%, respectively) [29].

In this study, to measure the pelvic inclination angle, the subjects stood on a flat surface with barefoot and looked at front while their legs were

as wide as their shoulders and their hands were crossed on their chests. Then, one arm of the tool was placed on the subjects' anterior superior iliac spine (ASIS) and the second one on their PSIS of the same side. The angle shown on the goniometer was reported as the anterior/posterior pelvic inclination angle [29,30].

2.3 Statistical Analysis

The SPSS version 16 was used to analyze the data and the graphs were plotted by Excel 2010. α was set at 0.05 as the significance level and the paired t-test, repeated measures ANOVA and Independent t-test were used for statistical analysis.

3. RESULTS

3.1 Pilto Study

Before starting the main study, the repeatability of the flexible ruler used in this study was tested

and found as 0.87 and the pelvic inclinometer as 0.91. To find out if the data are normally distributed, a Kulmogrov-Smrinov statistical analysis was used ($P>.05$). Since the data were normally distributed, the parametric statistics were used in this study.

3.2 Descriptive Analysis

Based upon our inclusion and exclusion criteria, fifty women were recruited in this study as the experimental group. However, twenty subjects were excluded (one for abortion, three for being high-risk pregnancy and 16 rejected the project for personal reasons) and the study ended with thirty subjects. These subjects were compared with eighteen age-BMI matched subjects as the control group. Table 1 shows the demographic characteristics of the subjects.



Fig. 1. The flexible ruler used in this study to measure the spinal curves



Fig. 2. The pelvic inclinometer used in this study to measure the pelvic inclination angle

The control group was also tested twice at the beginnings and end of the project (weeks 10th and 32nd). Using a paired t-test analysis showed that all measured data in control group had no significant difference with each other ($P>.05$). The data here mentioned for the control group are nearly similar to those measured at the beginning (week 10th).

Tables 2-4 show the absolute degrees and statistical analysis of the lumbar and thoracic curvatures and pelvic inclination angles of the control group and pregnant women at their first, second and third trimesters of pregnancy.

As Table 2 shows, the values of lumbar curvature angles were significantly different

between the control and experiment groups in the second and third trimesters. Although the lumbar curvature angle increased gradually in each trimester, it was significant only between the first and second; and the first and third trimesters. No significant difference was found between the second and third trimester and between the first trimester and control group.

Regarding the thoracic angle, Table 3 showed an increased curvature angle during pregnancy, but was only significant between the first and third; and between the second and third trimesters of pregnancy ($P<.05$). No significant difference was found between the angle of the first and second trimester or with the control group ($P>.05$).

Table 1. Demographic characteristics of the subjects (mean ± standard deviations)

Characteristics	Pregnant (N=30)	Non-pregnant (N=18)	P (independent t-test)
Age (Years old)	25.4±0.7	23.9±0.4	.643
Height (Cm)	160.8±0.9	163.4±1.5	.233
Weight (Kg)	61.5±1.9	61.3±2	.948
BMI (kg/m ²)	23.8±0.7	23±0.6	.427

BMI= body mass index

Table 2. The lumbar angle changes during pregnancy

Criteria	Control group	Pregnant women (Trimesters)				Post hoc test (Bonferroni) & independent t-test		
		1	2	3	ANOVA	Within groups	P	Changes (%)
Lumbar angles (°)	45±2.8	46.9±2	51.7±2.5	54.3±2.3	.012*	T1 vs. T2	.031*	+ 10.3%
						T1 vs. T3	.007*	+ 15.7%
						T2 vs. T3	.337	+ 4.8%
						T1 vs. C	.28	+ 4.2%
						T2 vs. C	.035*	+ 15%
T3 vs. C	.004*	+ 20.5%						

*= Significant difference, C= Control group, T=Trimester, (°)= Degree

Table 3. The thoracic angle changes during pregnancy

Criteria	Control group	Pregnant women (Trimesters)				Post hoc test (Bonferroni) & independent t-test		
		1	2	3	ANOVA	Within groups	P	Changes (%)
Thoracic angles (°)	30±1.2	32.4±1.8	34±1.6	37.9±1.3	.006*	T1 vs. T2	.396	+ 4.9%
						T1 vs. T3	.001*	+ 16.7%
						T2 vs. T3	.025*	+ 11.2%
						T1 vs. C	.272	+ 8%
						T2 vs. C	.049*	+ 13.3%
T3 vs. C	>.001*	+ 26.1%						

*= Significant difference, C= Control group, T=Trimester, (°) = Degree

Table 4. The pelvic inclination angle changes during pregnancy

Criteria	Control group	Pregnant women (Trimesters)			ANOVA	Post hoc test (Bonferroni) & independent t-test		
		1	2	3		Within groups	P	Changes (%)
Pelvic Inclination Angles (°)	7.5 ±0.5	10.9±0.5	13.9±0.4	17.7±0.7	.001*	T1 vs. T2	>.001*	+ 27.2%
						T1 vs. T3	>.001*	+ 62.4%
						T2 vs. T3	>.001*	+ 27.6%
						T1 vs. C	>.001*	+ 45.3%
						T2 vs. C	>.001*	+ 84.9%
T3 vs. C	>.001*	+ 236%						

*= Significant difference, C= Control group, T=Trimester, (°) = Degree

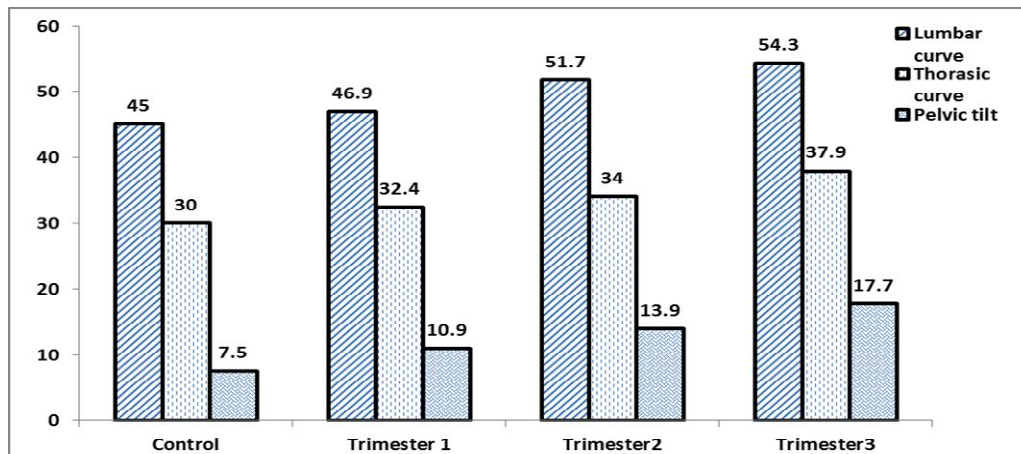


Fig. 3. Changes of the lumbar and thoracic curvatures and pelvic tilt in each trimester of pregnancy and in control group

Table 4 revealed a huge increased anterior pelvic tilt during pregnancy between the control and experimental groups and among all trimesters in the experimental group ($P < .001$) (Fig.3).

4. DISCUSSION

The marked postural changes following pregnancy may affect on the musculo-skeletal system and functional abilities of pregnant women [1]. The mal-alignments of the spinal column during pregnancy resulting from physiological and biomechanical changes may be associated with pain and disabilities [31]. However, a deliberate review of the literature showed that a controversy still exist regarding the exact spinal curvature changes as pregnancy advances.

The current study intended to track the postural changes during the first, second and third trimesters in primigravid pregnant women. The

current results showed increased angles in both lumbar and thoracic curvatures and anterior pelvic inclinations. In fact, the lumbar lordosis significantly increased when the first trimester was compared with the second and third ones. However, the increased angle was not significant between the second and third trimesters. The thoracic curvature, however, showed significantly increased curvature between the first and third and between the second and third trimesters. None of the lumbar or thoracic curve showed significantly difference between the control group and pregnant women during the first trimester of pregnancy. In other word, although ten weeks pregnancy increased lumbar lordosis and thoracic kyphosis (4.2%, 8%, respectively), but it was not significant when compared with the non pregnant women. The pelvic inclination angle showed to be more sensitive than spinal curvatures as it showed significant increase within all trimesters and when compared to the control group. Interestingly, it increased nearly 2.5 times more at the end of pregnancy (236%).

The findings of the current study was in agreement with some previous research [1,2,5,8,14,19,32], but disagreed with some others [4,6,7,9]. lumbar lordosis is the key postural component in maintaining sagittal balance. Affection of lumbar lordotic curve often results in sagittal spinal imbalance causing low back pain that represents one of the leading causes of disability [33]. Increased lumbar and thoracic curvatures and pelvic inclination angles during pregnancy might be due to the some physiologic changes. It seems that, initially, pregnancy does not alter any curve shapes and all increased masses are suffered by the muscles located around the lumbar area (core stabilizers). After 12 weeks pregnancy, the uterus moves to the anterior, outward and upper part of the pelvis. Up to sixteen kilograms increased mass of both fetus and mother at the front of the abdomen will produce an anterior pelvic tilt [1,3]. This will, in turn, shifts the center of body mass and the line of gravity to the anterior and will pressurize more on the lumbar muscles. To compensate this force and to prevent falling in front, the lumbar curvature increases to let the line of gravity passes through its behind. As this study showed, in early pregnancy, the pregnant women compensate this anterior abdominal shift only by anterior pelvic tilt without any significant changes at the lumbar or thoracic curvatures [34]. As pregnancy progresses and the lumbar lordosis increases, the line of gravity will be forwarding more and the risk of falling increases again. To keep the line of gravity in its correct position, the thoracic curvature starts increasing in opposite direction (kyphosis) to return the line of gravity to the back of the lumbar curve to reduce pressures on the lumbar discs, places the head in front and reduces the compression and irritation of the dura matter and the synovial membrane of the facet joints in lumbar area [8,29]. With regards to this point that the literature has already showed a positive relationship between the lumbar and thoracic changes and vice versa [35] in human body, it can be deduced that usually the position of pelvis might be representing the global position of the whole spinal column [16]. In addition, due to the hormonal release, some positional changes occur in ribs before any enlargement of the uterus. These include increased sub-costal angle forcing the ribs to the upper and lateral sides of the thoracic cage, thus increasing about 2 Cm anterior-posterior diameter of the cage, elevating the diaphragm up to 4 Cm and a total 5-7 Cm increased thoracic cage enlargement are other reasons to have an

increased thoracic curvature [36]. The huge increased thoracic curvature angle at the third trimester of pregnancy (26% in this study) might be due to the enlarged breasts to prepare mothers for caring babies and breast feeding. This is associated with an increased scapular protraction, internal rotation of the upper limbs and rounding shoulders, which is so-called "mother posture" [36].

The pelvic tilt is controlled by contraction of the abdominals, hip flexors, hip extensors and spinal extensor muscles (two paired muscle groups). Any changes in strength and endurance of these muscles will result in pelvic tilt changes. This, in turn, may result in lumbar lordosis angle changes. For instance, over stretching and weakness of the abdominal muscles will result in increased lumbo-sacral angle. This over stretching will result in shortness of the hip flexors and lumbar extensor muscles [5,14]. Some researchers have also shown the increased length of the rectus abdominis muscle and its diastasis during pregnancy that have reduced functional abilities of pelvic stabilizer muscles with advancement of pregnancy. This weakness has even lasted for 8 weeks after the delivery [37].

The results of a study in the Queensland University introduce the length of the abdominal and lumbar extensor muscles as the best indicators for lumbar curvature angles. In details, the lumbar lordosis showed a significant positive correlation with the length of abdominal muscles ($r=0.209$, $p<.05$), but had a negative correlation with the lumbar extensor muscles ($r= -0.24$, $p<.05$). This means that the shortest lumbar extensor muscle length, the most lumbar curvature angle [38].

During pregnancy, hormonal release is likely known as one of the main factors affecting the joints laxities of mother [39,40]. Many studies have reported increased relaxin hormone during pregnancy and confirmed its effects on increased range of movements of the pelvic girdle and peripheral joints [41], although the time needed to return to its normal status is ambiguous yet [42]. Progesterone and estrogen are two well known hormones essential for maintaining salt and water balance during pregnancy. They will stimulate releasing a hormone called relaxin that makes ligaments to be more elastic and vulnerable against injuries. Literature has stressed the important role of progesterone and estrogen hormones on increasing mobility of the

musculo-skeletal systems to facilitate the delivery process [1]. Since these two hormones released during pregnancy remain in the body for at least six months post delivery, the hormonal changes might also be responsible for remaining increased spinal curvatures and pelvic inclination following the delivery [5,40]. The role of hormones producing joint laxities from previous deliveries was omitted in this study by studying only primigravid women. Marques et al reported different joint laxities in multiparus women after the first pregnancy [31].

In addition to all mentioned above, Collition et al. [43] stated that all postural changes during pregnancy including increased lumbar lordosis help pregnant women to be in a more stable position during pregnancy [2]. It can be deduced that all postural changes take place in pregnant women intend to reduce her postural sways via increased lumbar curve and anterior pelvic tilt as well as shifting her head to back [5]. Although the balance index was not studied in the current study, one can assume that the significant increased thoracic curvature angle at the end of pregnancy, when the weight of fetus and mother reaches to its highest level, occurs to compensate the severe increased lumbar lordosis helping her for not falling to the front [16].

As brief, the postural changes occur during pregnancy can be divided into the real and compensatory changes. The real changes happen to counteract with the increased weight of the fetus and mother, while the compensatory curvatures happen to return the balance to the spinal column [8,44]. In an interesting anthropometric study, Whitcome et al. [45] showed that these postural changes happen to make bipedal standing and walking available for pregnant women.

5. CONCLUSION

The current study clearly showed the obvious spinal curvature changes during all trimesters of pregnancy. In this study, all the lumbar, thoracic and pelvic tilt angles increased as the pregnancy advanced. The results of the current study encourages pregnant women to have postural cares including suitable exercises and possible using suitable supports to keep their spinal column in best positions during pregnancy. It can be inferred that although the increased curvatures occurred during pregnancy are involuntarily, keeping the spinal curves as

minimal as possible is recommended to have easier return to its normal pre-pregnancy position.

CONSENT

All authors declare that 'written informed consent was obtained from the patient for publication of this cohort study.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down by Shahid Beheshti Medical University's Ethical Committee.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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