Original Article:
Spatio-Temporal Gait Parameters During Pregnancy and Postpartum

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Citation

Submitted: Jan 11, 2018; Accepted: Apr 6, 2018; Published: May 15, 2018

Abstract: Background and Objectives: Gait can get altered due to various biomechanical changes that occurs during pregnancy and this can affect the overall load distribution on the lower limb joints. These compensations may lead to changes in the spatio-temporal gait variables during pregnancy and postpartum and hence it is necessary to understand them. Method: We conducted a cohort study in which 84 pregnant women were recruited at or before 12th week of gestation and were studied through various trimesters and postpartum. Seventy pregnant women participated in the study and the spatio-temporal gait parameters were recorded using the 3-D Step gait protocol on the Win-Track system through various trimesters of pregnancy and postpartum. Repeated measures ANOVA was used to analyze the changes across the time periods. Results: The spatio-temporal gait variables analyzed were step duration, double stance duration, swing duration, step length, gait cycle length and cadence. All the gait parameters showed a significant difference (p<0.05) across the measurement periods. The plantar surface area of the feet and the average peak pressure also exhibited a gradual increase in values with advancement of pregnancy and reduced in the postpartum period (p<0.05). Conclusion: Pregnant women tend to walk at slower speed, with reduced step length, cadence and increased single stance duration and double stance duration in the third trimester compared to the earlier trimesters. The plantar surface area and the average peak pressure also exhibited significant changes across the measurement periods. All the variables reverted back to the first trimester values at six weeks postpartum.

Key Words: Antenatal, Postnatal, Walking

Introduction:
Walking is a highly recommended physical activity in pregnant women as per the American College of Obstetrics and Gynecology (ACOG) guidelines and is also an integral part of day to day tasks. (1) An increased body weight during pregnancy increases the stress on the lower limb joints while walking. The mechanics of walking in them may be affected by anterior pelvic tilt, increased lumbar lordosis, knee hyper extension, decreased medial longitudinal arch height and increased length and width of the foot. These compensatory adaptations may affect the overall load distribution and biomechanics of the lower limbs. (2) Prevalence of various lower limb musculoskeletal dysfunctions during pregnancy has been well documented in the literature. (3) These musculoskeletal dysfunctions may lead to secondary gait deviations in pregnancy. Previous research has evaluated the spatio-temporal, kinematic and kinetic parameters of gait in pregnant women. The common spatio-temporal variables which have been analyzed are the stride length, step length, gait cycle length, step duration, stride duration and base of support. The study results have demonstrated an increase in the temporal variables and decrease in the spatial variables as pregnancy advances. (4-8)

Although previous longitudinal studies have analyzed the gait parameters during pregnancy, the sample size of these studies were relatively smaller to generalize the study results. (9-14) Few studies have also reported about alteration in the distribution of plantar pressure pattern during gait which could be a possible reason for plantalgie during pregnancy.(15-17) Hence there is a need to study the changes in the spatiotemporal variables of gait in pregnant women which may have an effect on the locomotor functions. The main purpose of this study was to evaluate the spatio-temporal gait parameters across various phases of pregnancy and postpartum. The study also aimed to evaluate the changes in plantar surface area and average peak pressure across the time periods.

Material and Methods
The study approval and ethical clearance was obtained from the Institutional Research Committee and University Ethics Committee respectively. The trial was registered under the Clinical Trial Registry of India (CTRI No:...
This study was a part of a larger cohort study which evaluated multiple outcome measures related to foot of pregnant women. Primigravidae with a singleton gestation with a gestational age of 12 weeks or less, aged between 18-35 years were included for the study. Pregnant women with previous history of musculoskeletal dysfunctions including existing flat feet, lower limb pain, back pain, hydramnios and fibroid complicating pregnancy were excluded from the study. The measurements were taken at 12th week, 24th week and 32nd week of gestation and at two different time periods in the postpartum period that is on the third day in case a woman had a normal vaginal delivery or the sixth postoperative day in case she had a caesarian section and at six weeks postpartum. A written informed consent was obtained from all the participants.

**Apparatus used:**

**Win-track system:** Win-track system (MEDICAPTEURS technology, France) consists of a gait platform with following dimensions: 1610 mm x 652 mm x 30 mm (length/width/height) and a thickness of 9 mm. It consists of 12,288 sensors which are of resistive type. The sizes of the sensors are 7.8x7.8mm and the acquisition frequency of the apparatus is up to 200 images/sec. The Win-Track system records three to four steps as the participant walks on it. Data are uploaded to the computer and automatic footstep identification and parameter calculations are made. This system directly supplies the clinician with quantitative information about gait parameters as shown in Figure 1.

![Figure 1: Results of the gait parameters as displayed on the screen](image)

The platform was placed in the center of a 10 meter long pathway. Instructions regarding the test procedure was given to all the participants before the commencement of the study. Based on the results of test-retest reliability of Win-Track system, 3-step gait protocol was used to evaluate the spatial and temporal gait parameters. The participants stood at the edge of the platform and took three steps forward outside the platform. A mark was made on the floor where the third heel struck and this mark was considered as the starting point. Three trials were given for practice and the participants stood at a distance such that they would correctly place the heel of the dominant foot at the beginning of the platform. This ensured that all the three footsteps were recorded. During the procedure, participants were instructed to look ahead and walk at their comfortable pace on the platform to prevent targeting. They continued to walk until the therapist instructed them to stop such that no deliberate attempts were made by the participants to decelerate as soon as they reached the end of the platform. The gait parameters which were recorded in the computer were taken for analysis. (18)

**Statistical analysis:**

Data was analyzed using SPSS version 15.0. Descriptive statistics was used for reporting all the demographic variables. Repeated measures ANOVA was used to report the changes in gait parameters across the time periods.

**Results**

The mean age of the primigravidae was 27.98±3.65 years and their mean height was 156.47±5.61 cm. The mean BMI (kg/m2) ranged between 23.08±4.17 in first trimester until 25.67±4.94 at 6 weeks postpartum. Although 84 participants were included for the study, there were 14 drop outs and the data of 70 pregnant women were taken up for the final analysis. The flow of participants is shown in Figure 2.

![Figure 2: Flow of study participants of the cohort study](image)

<table>
<thead>
<tr>
<th>Variables</th>
<th>12th week</th>
<th>24th week</th>
<th>32nd week</th>
<th>First reading at postpartum</th>
<th>6 weeks postpartum</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step duration (R°)(ms)</td>
<td>590 (547,610)</td>
<td>640(597.5,682.5)</td>
<td>710 (650,802.5)</td>
<td>620 (588.7,652.5)</td>
<td>590 (537.5,652.5)</td>
<td>0.030</td>
</tr>
<tr>
<td>Double stance duration (R°)(ms)</td>
<td>200 (160,262.5)</td>
<td>250 (207.5,325)</td>
<td>350 (250,440)</td>
<td>238.5 (197.5,312.5)</td>
<td>210 (168.7,265.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Swing duration (R°)(ms)</td>
<td>1300 (1230,1380)</td>
<td>1365 (1280,1450)</td>
<td>1480 (1390,1570)</td>
<td>1290 (1240,1397)</td>
<td>1279 (1220,1320)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Step length (R°)(mm)</td>
<td>577 (524.5,633)</td>
<td>500 (470,566)</td>
<td>432 (378,498.5)</td>
<td>522(476.5,576.5)</td>
<td>572(520,632.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gait cycle length (R°)(mm)</td>
<td>115(1039,1212.7)</td>
<td>1009(970,1089.7)</td>
<td>961(861,1003)</td>
<td>1083(1019,1170)</td>
<td>1126(1046,1210)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gait cycle length (L°)(mm)</td>
<td>1020(902,1114)</td>
<td>984.5(837.2,1027.5)</td>
<td>839.5 (753,962.5)</td>
<td>1007(923.5,1105.2)</td>
<td>1102(998,1172.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cadence</td>
<td>107.5(101.5,110)</td>
<td>100.8(95.5,103.8)</td>
<td>100(95.5,103.8)</td>
<td>96(88.5,98.9)</td>
<td>102.6(98.5,112.5)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

(*R=Right foot, **L=Left Foot)
Discussion

In our study, we found that the temporal variables showed a significant increase with advancement of pregnancy. These changes are more evident in the third trimester compared to the first and second trimester. The spatio-temporal variables reverted back to the first trimester values by six weeks postpartum.

Conclusion

The temporal and spatial parameters of gait significantly alters with advancement of pregnancy. These changes are more evident in the third trimester compared to the first and second trimester. The spatio-temporal variables reverted back to the first trimester values by six weeks postpartum.

References


Table 1 represents the changes in gait variables as measured when the pregnant women were made to walk over the Win-track system. We found that all the spatio-temporal gait variables demonstrated significant changes across the different measurement periods.

Table 2: Changes in plantar surface area and average pressure across different measurement periods (n=70)

<table>
<thead>
<tr>
<th>Area</th>
<th>First foot(cm²)</th>
<th>Second foot cm²</th>
<th>Third foot(cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Pressure (g/cm²)</td>
<td>90.1(77.5,101)</td>
<td>92.5(80.103.2)</td>
<td>99(81.7,110)</td>
</tr>
<tr>
<td></td>
<td>85(71.9,74.6)</td>
<td>85(71.974)</td>
<td>85(81.5,95)</td>
</tr>
<tr>
<td></td>
<td>73(63,90)</td>
<td>73(62,82.7)</td>
<td>69(57,76)</td>
</tr>
</tbody>
</table>

The gradual increase in temporal variables further ensures that the plantar surface area occupied by the foot increases with pregnancy. The average peak pressure also exhibited a gradual increase with advancement of pregnancy and reduced post-delivery. The increase in body weight, increased plantar surface area and increase in temporal variables might result in increased average peak pressure during pregnancy.

This study is the largest cohort study which has analyzed the gait variables across various trimesters of pregnancy and postpartum and hence the results are generalizable. Future studies can focus on influence of footwear and exercises on these parameters.

Table 2: Changes in plantar surface area and average pressure across different measurement periods (n=70)

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<th>Second foot cm²</th>
<th>Third foot(cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Pressure (g/cm²)</td>
<td>1226(1026,1316.6)</td>
<td>1250(1087,1342)</td>
<td>1243(1102,1533)</td>
</tr>
<tr>
<td></td>
<td>1254(1089,1479)</td>
<td>1232(1017,1432)</td>
<td><strong>&lt;0.001</strong></td>
</tr>
</tbody>
</table>

An increase in the values of temporal variables indicate that the pregnant women walked slowly as the pregnancy progressed which may be associated with their postural instability. It is further justified by the fact that the cadence reduced as the pregnancy advanced. (13) Pregnant women tend to keep their feet on the ground for longer period of time during the gait cycle in order to support their increased body weight and to ensure better stability. Inability to see the surface just beneath them from second trimester onwards could be the reason for this cautious gait pattern. (15)

The altered posture during pregnancy causes the center of weight and to ensure better stability. Inability to see the surface just beneath them from second trimester onwards could be the reason for this cautious gait pattern. (15)

The transverse plane range of motion at the pelvic segment and reduced arch height may be the possible reasons for a linear trend with a peak rise in the third trimester and a gradual reduction in the postpartum period. (Table 2) A gradual increase in body weight along with pronation of foot and reduced arch height may be the possible reasons for this. (18,23,24) The gradual increase in temporal variables further supports our study results.

We found in our results that the area occupied by the plantar surface of the feet increased with pregnancy and demonstrated a linear trend with a peak rise in the third trimester and a gradual reduction in the postpartum period. (Table 2) A gradual increase in body weight along with pronation of foot and reduced arch height may be the possible reasons for this. (18,23,24) The gradual increase in temporal variables further...