International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

Gait Analysis during Pregnancy

Dinesh Sorani[1], R D Jani[2], Nalini Anand[3]

[1]Senior Lecturer, Government Physiotherapy College, Jamnagar, Gujarat, India.
[2]Professor, C U Shah Medical College, Surendranagar, Gujarat, India.
[3]Professor, Shri M P Shah Government Medical College, Jamnagar, Gujarat, India.

Corresponding Author: Dinesh Sorani

Received: 03/03/2016 *Revised: 28/03/2016* *Accepted: 28/03/2016*

ABSTRACT

Introduction: The body undergoes many physiological changes during pregnancy which may lead to gait deviation. The present study targets analysis of gait during pregnancy by foot print method.
Methodology: Total 322 subjects participated in the study whose footprints were collected and analyzed by Wilkinson method.
Results and Conclusion: Gait speed decreases significantly during pregnancy as compared to the speed of nonpregnant subjects.

Keywords: Gait; Pregnancy; Footprint.

INTRODUCTION

Throughout the duration of pregnancy the hormonal, anatomical and physiological changes occur that alter the body-mass distribution, joint laxity and musculotendinous strength. [1] Body mass increases by a mean of eleven kilograms and body-mass distribution changes as the growing fetus increases the low anterior load on the trunk. In addition, hormonal changes alter joint laxity.

During pregnancy musculoskeletal disorders are common and cause problems ranging from mild discomfort to serious disability. Some of these conditions include low back pain involving the lumbosacral spine and sacroiliac joints, carpal tunnel syndrome and leg cramps. [2-4]

Presence of these anatomical and physiological changes with or without the presence of musculoskeletal disorders can result into alteration of walking pattern. Altered gait pattern may subsequently alter the biomechanics and may worsen the discomforts and disabilities as a result of vicious cycle.

There are very few researches done on gait deviation during pregnancy and the current knowledge about these gait deviation is limited. The current study is targeting assessment of gait deviations during pregnancy during first, second and third trimesters of pregnancy and comparing them with normal values.

Recently gait analysis has undergone technological advancements. However footprint data still can provide a simple and inexpensive and reliable method for measuring a gait. [5,6]

During pregnancy, a woman changes obviously in body weight, body shape, and endocrine system. Those changes make the posture and gait pattern of the pregnant women different from those of the non-pregnant women.

The overall speed of walking is reduced in pregnancy with prominent changes during third trimester. [7-13]

According to some authors the speed does not change during pregnancy. [14] Walking velocity may be affected by history of fall. [15] Cadence may decrease [11] or remain normal. [14] Step length and stride length reduces [11,12,16] or may remain normal [1,14,17] during pregnancy. Base of gait increases significantly during third trimester of pregnancy. [1,11,17] Stance time increases [18] although Branco et al [12] did not find significant change. Foot progression angle does not show any deviation from normal pattern. [14]

Anterior pelvic tilt increases during pregnancy. The same change is also evident during walking along with increased maximum hip flexion. [8,9,14] Although, some authors did not find any difference in hip flexion angle during walking. [11,12] Stance phase hip adduction may increase [14] or may remain unchanged. [11,12] Knee flexion may increase during midstance [8] or remain unchanged. [11,12] Ankle dorsiflexion may reduce [8,9] or remain unchanged. [11,12] Trunk tilt and trunk obliquity and trunk rotation angles during walking remain similar to that of nonpregnant women. [13,14]

TsanHsun et al [19] suggested the following kinetic changes during gait in pregnancy. They attributed these changes to sacroiliac pain during pregnancy.

- Increase of hip extension moment
- Decreased knee extension moment
- Decreased ankle planter flexion moment
- Increased knee adduction moment

Although resting metabolic rate increases overall metabolic cost of walking is reduced due to adaptations made in walking during pregnancy. [10]

Currently no data is available on gait analysis during pregnancy in India. Evaluation of gait may help to find adaptations made by pregnant women to compensate for physiological changes acquired during pregnancy. This may be the first study analyzing gait of pregnant women in the area of Jamnagar city in the state of Gujarat, India.

The aims and objectives of the current study are as follows

Quantitative analysis of gait parameters like velocity, cadence, step length (both side as well as combined), stride length (both side as well as combined), foot angle in relation to central line of progression (both side as well as combined), foot angle in relation to ipsilateral line of progression (both side as well as combined) and base of gait during first, second and third trimesters of pregnancy.

- To compare the data collected from pregnant females with age matched non-pregnant females.
- To compare the gait parameters between first, second and third trimester of pregnancy.

METHODOLOGY

Full approval was obtained from the M P Shah medial college Research Ethical committee.

The subjects were selected based on inclusion and exclusion criteria from Gynecology and Obstetrics department outpatient department of Guru Gobindsingh Hospital, Jamnagar

Inclusion criteria

- Subjects willing to participate in the study
- Primigravida or multigravida in 1st, 2nd, or 3rd trimester of their pregnancy
- Nulliparous women

Exclusion criteria

- Women with any musculoskeletal pathology that is unrelated to changes occurring during pregnancy

The subjects were selected randomly based on inclusion and exclusion criteria from Gynecology and Obstetrics department outpatient department of Guru Gobindsingh Hospital, Jamnagar. Each subject was given ‘Patient information sheet’ in their understandable language and was explained properly about the purpose of the study. The subjects signed the ‘Informed consent form’ prior to the collection of data.

Basic information like name, age, height and weight were assessed first. The subjects were asked if they had any

musculoskeletal problems like back pain, neck pain, leg cramps or swelling. Those with such complaints were assessed and were ruled out if the cause of such symptoms were other than that of pregnancy related changes.

The subjects were asked to walk for practice at their self-selected speed with bare feet on a 15 inch wide paper strip fixed by tape on the floor which was at least 35 feet long. While the subjects walked for practice their cadence and velocity was measured.

After the practice walk the subjects' feet were inked with stamp pad ink while they stood in the tray filled with ink. Once the feet were inked the subjects were asked to walk on the paper at their self-selected speed.

The ink was allowed to dry and then the paper was folded and analyzed afterwards.

Wilkinson et al [6] have described a method where he has provided precise definitions of reference points and how the various lines and angles are drawn. The method can be used when the subjects were barefoot or when they were wearing shoes, which would be broadly applicable and can be used with special populations e.g. children or those with gait abnormalities. The method is inexpensive and easy to perform.

Data analysis

The data collected was compiled using Microsoft Excel 2013 and then transferred to SPSS for statistical analysis. The subjects were divided into four groups.

Group 1: Control Group
Group 2: First Trimester Group
Group 3: Second Trimester Group
Group 4: Third Trimester Group

The demographic data (age, height, weight and BMI) were first compared using one way ANOVA test to find the homogeneity of groups.

Followed by this the quantitative gait parameters (speed, cadence, step length on left side, step length on right side, step length-combined, stride length on left side, stride length on right side, stride length-combined, base of support, foot angle with ipsilateral line of progression (ILOP) on left side, foot angle with ILOP on right side, foot angle with ILOP-combined, foot angle with central line of progression (CLOP) on left side, foot angle with CLOP on right side, AND foot angle with CLOP-combined) were compared using one way ANOVA test to find the difference. Level of Significance was 0.05 for all the tests.

RESULTS

Total 372 subjects were randomly selected and included in the study based on inclusion and exclusion criteria. Out of 372 subjects, 50 subjects were excluded due to non-compliance with the foot print analysis methods and poor quality of foot print data.

Demographic variables like age, height, weight and BMI were compared for variances by using one way ANOVA.

Table 1: Group wise distribution of subjects

Group	Number of subjects
First trimester	87
Second trimester	91
Third trimester	101
Control	43
Total	322

Table 2: ANOVA for age, height, weight and BMI

		Sum of Squares	df	Mean Square	F	Sig.
AGE	Between Groups	4.38	3	1.46	.13	.938
	Within Groups	3404.26	318	10.70		
	Total	3408.64	321			
HEIGHT	Between Groups	8.14	3	2.70	.07	.973
	Within Groups	11197.25	318	35.21		
	Total	11205.39	321			
WEIGHT	Between Groups	2509.52	3	836.50	9.80	.000
	Within Groups	27131.57	318	85.31		
	Total	29641.00	321			
BMI	Between Groups	471.30	3	157.13	11.20	.000
	Within Groups	4459.51	318	14.02		
	Total	4930.98	321			

Gait parameters were compared between groups using ANOVA.

Table 3: ANOVA for gait parameters

		Sum of Squares	df	Mean Square	F	Sig.
SPEED	Between Groups	9.859	3	3.286	101.376	.000
	Within Groups	10.309	318	.032		
	Total	20.168	321			
CADENCE	Between Groups	29024.206	3	9674.735	43.582	.000
	Within Groups	70593.078	318	221.991		
	Total	99617.283	321			
STP_L_LT	Between Groups	5503.347	3	1834.449	38.567	.000
	Within Groups	15125.890	318	47.566		
	Total	20629.237	321			
STP_L_RT	Between Groups	4831.499	3	1610.500	37.338	.000
	Within Groups	13716.326	318	43.133		
	Total	18547.826	321			
STP_L	Between Groups	5106.773	3	1702.258	40.444	.000
	Within Groups	13384.499	318	42.090		
	Total	18491.272	321			
STR_L_LT	Between Groups	19667.757	3	6555.919	40.437	.000
	Within Groups	51555.697	318	162.125		
	Total	71223.455	321			
STR_L_RT	Between Groups	20513.161	3	6837.720	42.576	.000
	Within Groups	51070.451	318	160.599		
	Total	71583.612	321			
STR_L	Between Groups	20085.892	3	6695.297	41.682	.000
	Within Groups	51079.959	318	160.629		
	Total	71165.852	321			
BOS	Between Groups	95.760	3	31.920	3.266	.022
	Within Groups	3108.217	318	9.774		
	Total	3203.977	321			
CLOP_LT	Between Groups	656.374	3	218.791	5.768	.001
	Within Groups	12062.098	318	37.931		
	Total	12718.472	321			
CLOP_RT	Between Groups	707.151	3	235.717	6.604	.000
	Within Groups	11350.473	318	35.693		
	Total	12057.624	321			
CLOP	Between Groups	634.828	3	211.609	7.894	.000
	Within Groups	8524.371	318	26.806		
	Total	9159.199	321			
ILOP_LT	Between Groups	669.916	3	223.305	6.120	.000
	Within Groups	11602.177	318	36.485		
	Total	12272.092	321			
ILOP_RT	Between Groups	745.790	3	248.597	6.849	.000
	Within Groups	11541.980	318	36.296		
	Total	12287.770	321			
ILOP	Between Groups	700.819	3	233.606	8.750	.000
	Within Groups	8489.924	318	26.698		
	Total	9190.742	321			

STPL_L_LT (step length on left side), STPL_L_RT (step length on right side), STPL_L combined step length on both side, STR_L_LT (stride length on left side), STR_L_RT (stride length on right side), STR_L combined stride length on both side, BOS Base of support during gait

The groups were homogenous in age and height. Weight and BMI were higher in second and third trimester groups, however considering physiological changes these changes were acceptable.

DISCUSSION

As seen in Table 1, the control and first trimester group are homogenous and have similar characteristics for weight and BMI and all groups were homogenous for age and height.

Gait parameters were compared between groups using ANOVA. The gait speed decreased significantly during pregnancy in all groups as compared to control group. Similarly the cadence also decreased significantly during pregnancy in all groups as compared to control group. There was significant reduction of step length and stride length in first, second and third trimester groups as compared to control group. The base of gait was not significantly altered. Foot angle was reduced in control group as compared to other groups. Musculoskeletal symptoms did not have any impact on any of the gait parameters.

Studies by Wu et al (2008), [7] Hagan et al (2008), [8] Hagan et al (2010), [9] Byrne et al (2011), [10] Wanda et al (2012), [11] Branco et al (2013) [12] and Wu et al (2004) [13] show that maximum reduction in walking velocity occurs in third trimester. In the present study the average velocity of third trimester was slightly higher but statistically insignificant than the average velocity of second trimester which was lowest amongst all groups. Results of the present study suggest that the subjects might have adapted the strategies to accommodate the physical changes resulting in arrest of further reduction of velocity in third trimester.

With reduction in gait velocity the cadence also decreases. Lower cadence value increases gait cycle time and thus is a part of adaptive strategy to adapt the challenges during walking.

As the speed of gait decreases it is associated with reduced step length. However it is not implied in the results of the present study. It appears that from the first trimester onwards the subjects tend to walk with smaller step length. Although the third trimester group can be justified by the presence of physical and physiological changes present, reason for smaller step length in the first trimester is unclear. According to the authors of the present study it may be attributed to the psychological status of the pregnant women due to culture of Indian Society where the pregnant women must be taken care of. It may be the cultural influence that with the knowledge of being pregnant the women may take extra precautions by walking slowly even during the first trimester. The authors could not find any literature supporting this hypothesis nor were the psychological and cultural aspects of the participants analyzed. Further study including the influence of culture and psychological status on gait may provide additional information of this deviation.

The Base of gait (Also known as base of support) reduces from first trimester and achieves nearly normal value in the third trimester. Although the step length and stride length are not significantly altered in second and third, smaller base of gait in first trimester appears to be associated with reduced step length. However authors cannot find any biomechanical association with smaller step/stride length and a narrow base of gait. As the physiological adaptions by the body like weight gain, altered posture and shift in center of gravity are more likely to appear in third trimester, such presentation of smaller base of gait cannot be explained by these changes. There are no studies supporting this finding and further research is suggested.

Higher speed values along with longer step/stride lengths may have an influence on foot angle. Although the speed and step length are not significantly altered in second and third trimesters, smaller values in these groups as compared to control group may be seen as a strategy to increase dynamic balance during walking. As the foot angle increases the total transverse distance between anterolateral borders of foot is increases which contribute into lateral stability.

CONCLUSION

The women with pregnancy walk slowly with smaller steps and stride. They also walk with more outward angle of foot while walking.

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How to cite this article: Sorani D, Jani RD, Anand N. Gait analysis during pregnancy. Int J Health Sci Res. 2016; 6(4):266-271.

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