ORIGINAL ARTICLE e-ISSN: 2349-0659 p-ISSN; 2350-0964

Kinetic Evaluation of Pelvis during the Three Trimesters of Pregnancy and its Correlation to BMI

Prachiti A. Dhuru, Suraj B. Kanase*

Abstract

Background: Understanding differences in mechanics between pregnant and non-pregnant females are a first step toward identifying potential pathological mechanisms. **Objectives:** The objective was to investigate systematic changes in the range of motion of pelvis in all three trimesters of pregnancy and its correlation to BMI. **Materials and Methods:** One hundred and seventy-four primigravida pregnant females with age group of 20–30 years completed testing on three occasions (first trimester, second trimester, and third trimester) using goniometer. The patient was made comfortable and her height, weight was measured to calculate the BMI. Later with the help of goniometer range of motion of pelvis (hip and lumbar) was measured. **Results:** In this study, *significant correlation* was seen for anterior pelvic tilt, posterior pelvic tilt, and backward rotation for the first and third trimester. *Very significant correlation* was seen for anterior pelvic tilt, posterior pelvic tilt, lateral pelvic tilt, forward rotation, backward rotation in the second trimester, and for backward rotation in the third trimester. *Extremely significant correlation* was seen for posterior pelvic tilt in the first trimester, for anterior and posterior pelvic tilt in the second trimester, for posterior pelvic tilt in the third trimester. **Conclusion:** In this study, *significant correlation* was seen for the first and third trimester. *Very significant correlation* was seen for the second trimester and for third trimester. *Extremely significant correlation* was seen in the first trimester, second trimester, and third trimesters.

Keywords: BMI, Kinetics, Pelvis, Pregnancy, Trimesters

Asian Pac. J. Health Sci., (2022); DOI: 10.21276/apjhs.2022.9.4S.51

Introduction

There is tremendous increase in size and weight of the fetus during third trimester of pregnancy, wherein there is 50% additional weight of the fetus.[1,2] There are superior and posterior shifts of woman's center of gravity due to developing breasts and increase in lumbar lordosis which also leads to addition in abdominal weight and volume in pregnant woman.[1,3] Certain studies were conducted to justify joint kinetics in pregnant females[4-9] and for the purpose to utilize body mass normalized moments.[5,6,7,9] Understanding differences in mechanics between pregnant and non-pregnant females are a first step toward identifying potential pathological mechanisms. The objective was to investigate systematic changes in the range of motion of the pelvis and its correlation to BMI. There is possibility of altered ROM with respect to trimesters of pregnancy. As pregnancy is characterized by continuous changes over time, changes may be expected to show systematic trends as the pregnancy progresses.[10]

Materials and Methods

The purpose of the study was explained, which was explained and written consent was taken from subjects willing to participate. Subjects were selected for the study according to the selection criteria. *Inclusion criteria* were subjects between 20 and 30 years of age, primigravida females (pregnant for the first time), BMI ranging from lean body weight, normal, and obese body weight. Exclusion criteria included multigravida females and genetic abnormality. The study type was observational study. The study design was survey. Sampling method used was simple random sampling technique.

Participants

One hundred and seventy-four pregnant females were recruited. Pregnant females were included if they were 20–30 years old, primigravida and in all the three trimesters, that is, 1st–3rd month, 4th–6th month, and 7th–9th month. All participants signed the approved informed consent form and pregnant participants obtained written consent from the obstetrician before participation.

Instrumentation

Pelvic kinetics was collected using goniometer method. The goniometer has three parts: (1) Fulcrum, (2) moving arm, and (3) fixed arm. Fulcrum: Placed over a joint example hip joint for assessing the hip flexion – extension. Moving arm: Placed over the part which is to be moved example lateral midline of femur for assessing hip flexion-extension. Fixed arm: placed over proximal part of the body which is not moved example lateral midline of pelvis which is used for assessing hip flexion-extension.

Procedure

The patient was made comfortable and her height, weight was measured to calculate the BMI. Later with the help of goniometer

Department of Neurosciences, Krishna College of Physiotherapy, Krishna Institute of Medical Sciences (Deemed to be University) Karad, Malkapur, Maharashtra, India.

Corresponding Author: Dr. Suraj B. Kanase, Department of Neurosciences, Krishna College of Physiotherapy, Krishna Institute of Medical Sciences (Deemed to be University), Karad, Malkapur, Maharashtra, India. E-mail: drsurajkanase7@gmail.com

How to cite this article: Dhuru PA, Kanase SB. Kinetic Evaluation of Pelvis during the Three Trimesters of Pregnancy and its Correlation to BMI. Asian Pac. J. Health Sci., 2022;9(4S):269-276.

Source of support: Nil

Conflicts of interest: None.

Received: 04/04/2022 **Revised:** 09/05/2022 **Accepted:** 28/05/2022

Table 1 : First trimester: Normal BMI: 23 primigravida women with average (BMI=20.83)

Motions	*R*	*r2*	*P*	*C.I.*
Hip flexion	0.05248	0.002754	0.8120	−0.3678–0.4549
Hip extension	0.07993	0.006388	0.7170	−0.3437–0.4765
Hip abduction	−0.4445	0.1976	0.0336	−0.7241–−0.03940
Hip adduction	0.2837	0.08051	0.1895	−0.1456–0.6231
Hip medial rotation	−0.2331	0.05433	0.2845	−0.5888–0.1983
Hip lateral rotation	0.1903	0.03620	0.3845	−0.2409–0.5587
Lumbar lateral flexion	0.1164	0.01356	0.5967	−0.3108–0.5045
Lumbar flexion	0.01845	0.0003403	0.9334	−0.3969–0.4275
Lumbar extension	−0.3277	0.1074	0.1269	−0.6519–0.09777

*r: Correlation coefficient, C.I: 95% confidence interval, r2: Coefficient of determination

Table 2: Underweight BMI: 4 primigravida women with average (BMI=17.85)

Motions	*R*	*r2*	*P*	*C.I.*
Hip flexion	−0.9847	0.9697	0.0153	−0.9997–−0.4409
Hip extension	−0.9994	0.9988	0.0006	−1.0000–−0.9705
Hip abduction	−0.9394	0.8825	0.0606	−0.9988–0.2237
Hip adduction	−0.9394	0.8825	0.0606	−0.9988–0.2237
Hip medial rotation	0.1741	0.0303	0.8259	−0.9452–0.9725
Hip lateral rotation	−0.9394	0.8825	0.0606	−0.9988–0.2237
Lumbar lateral flexion	0.7107	0.5051	0.2893	−0.7902–0.9933
Lumbar flexion	0.1741	0.03030	0.8259	−0.9452–0.9725
Lumbar extension	0.9864	0.9731	0.0136	0.4877–0.9997

*r: Correlation coefficient, C.I.: 95% confidence interval, r2: Coefficient of determination

Table 3: Obese BMI: 4 primigravida women with average (BMI=26.25)

Motions	*R*	*r2*	*P*	*C.I.*
Hip flexion	−0.9507	0.9037	0.0493	−0.9990–0.1213
Hip extension	0.7276	0.5294	0.2724	−0.7766–0.9938
Hip abduction	0.983	0.9663	0.017	0.3962–0.9997
Hip adduction	0.9802	0.9608	0.0198	0.3293–0.9996
Hip medial rotation	0.7276	0.5294	0.2724	−0.7766–0.9938
Hip lateral rotation	−0.8868	0.7865	0.1132	−0.9976–0.5031
Lumbar lateral flexion	−0.8893	0.7908	0.1107	−0.9977–0.4944
Lumbar flexion	−0.7683	0.5903	0.2317	−0.9948–0.7371
Lumbar extension	0.9507	0.9037	0.0493	−0.1213–0.9990

*r: Correlation coefficient, C.I.: 95% confidence interval, r2: Coefficient of determination

Table 4: Second trimester: Normal BMI: 41 primigravida women with average (BMI=21.85)

Motions	*R*	*r2*	*P*	*C.I.*
Hip flexion	0.5354	0.2867	0.0003	0.2726–0.7239
Hip extension	0.5454	0.2975	0.0002	0.2856–0.7305
Hip abduction	0.2725	0.07427	0.0847	−0.03842–0.5354
Hip adduction	0.2616	0.06844	0.0985	−0.05015–0.5269
Hip medial rotation	0.06893	0.004752	0.6685	−0.2440–0.3688
Hip lateral rotation	−0.07181	0.005156	0.6555	−0.3713–0.2412
Lumbar lateral flexion	−0.05519	0.003046	0.7318	−0.3569–0.2569
Lumbar flexion	0.1642	0.02696	0.3050	−0.1512–0.4492
Lumbar extension	0.4661	0.2172	0.0021	0.1849–0.6767

*r: Correlation coefficient, C.I.: 95% confidence interval, r2: Coefficient of determination

Table 5: Underweight BMI: 8 primigravida women with average (BMI=16.6)

Motions	*R*	*r2*	*P*	*C.I.*
Hip flexion	−0.4240	0.1798	0.2951	−0.8691–0.4004
Hip extension	−0.8553	0.7316	0.0068	−0.9734–−0.3791
Hip abduction	−0.8113	0.6582	0.0145	−0.9646–−0.2487
Hip adduction	−0.5580	0.3114	0.1506	−0.9063–0.2419
Hip medial rotation	−0.8113	0.6582	0.0145	−0.9646–−0.2487
Hip lateral rotation	−0.8513	0.7246	0.0073	−0.9726–−0.3662
Lumbar flexion	0.1593	0.02537	0.7064	−0.6145–0.7769
Lumbar extension	−0.04265	0.001819	0.9201	−0.7256–0.6827
Lumbar lateral flexion	−0.8113	0.6582	0.0145	−0.9646–−0.2487

*r: Correlation coefficient, C.I.: 95% confidence interval, r2: Coefficient of determination

Table 6: Obese BMI: 16 primigravida women with average (BMI=29.9)

Motions	*R*	*r2*	*P*	*C.I.*
Hip flexion	−0.8153	0.6647	0.0001	−0.9337–−0.5363
Hip extension	−0.7829	0.6129	0.0003	−0.9211–−0.4691
Hip abduction	−0.6147	0.3778	0.0113	−0.8511–−0.1710
Hip adduction	−0.5258	0.2765	0.0364	−0.8104–−0.04057
Hip medial rotation	−0.6413	0.4112	0.0074	−0.8628–−0.2133
Hip lateral rotation	−0.2984	0.08904	0.2616	−0.6919–0.2317
Lumbar flexion	0.01384	0.0001916	0.9594	−0.4853–0.5062
Lumbar extension	0.2572	0.06616	0.3362	−0.2735–0.6679
Lumbar lateral flexion	−0.4145	0.1718	0.1104	−0.7551–0.1024

*r: Correlation coefficient, C.I.: 95% confidence interval, r2: Coefficient of determination

Table 7: Third trimester: Normal BMI: 23 primigravida women with average (BMI=21.58)

Motions	*R*	*r2*	*P*	*C.I.*
Hip flexion	−0.2292	0.05251	0.1495	−0.5015–0.08452
Hip extension	−0.1651	0.02727	0.3021	−0.4500–0.1502
Hip abduction	0.04460	0.001989	0.7819	−0.2668–0.3476
Hip adduction	0.03857	0.001488	0.8108	−0.2724–0.3422
Hip medial rotation	0.2412	0.05816	0.1288	−0.07189–0.5110
Hip lateral rotation	0.4015	0.1612	0.0093	0.1069–0.6312
Lumbar lateral flexion	−0.1877	0.03524	0.2399	−0.4684–0.1274
Lumbar flexion	0.1784	0.03182	0.2645	−0.1369–0.4608
Lumbar extension	−0.3397	0.1154	0.0298	−0.5861–−0.03570

*r: Correlation coefficient, C.I.: 95% confidence interval, r2: Coefficient of determination

Table 8: Underweight BMI: 4 primigravida women with average (BMI=69.7)

Motions	*R*	*r2*	*P*	*C.I.*
Hip flexion	0.7686	0.5908	0.2314	−0.7368–0.9948
Hip extension	0.08737	0.007634	0.9126	−0.9539–0.9673
Hip abduction	0.8575	0.7354	0.1425	−0.5892–0.9970
Hip adduction	0.7863	0.6183	0.2137	−0.7157–0.9953
Hip medial rotation	0.8693	0.7557	0.1307	−0.5581–0.9972
Hip lateral rotation	0.9885	0.9771	0.0115	0.5478–0.9998
Lumbar lateral flexion	−0.7863	0.6183	0.2137	−0.9953–0.7157
Lumbar flexion	0.08737	0.007634	0.9126	−0.9539–0.9673
Lumbar extension	−0.1236	0.01527	0.8764	−0.9695–0.9504

*r: Correlation coefficient, C.I.: 95% confidence interval, r2: Coefficient of determination

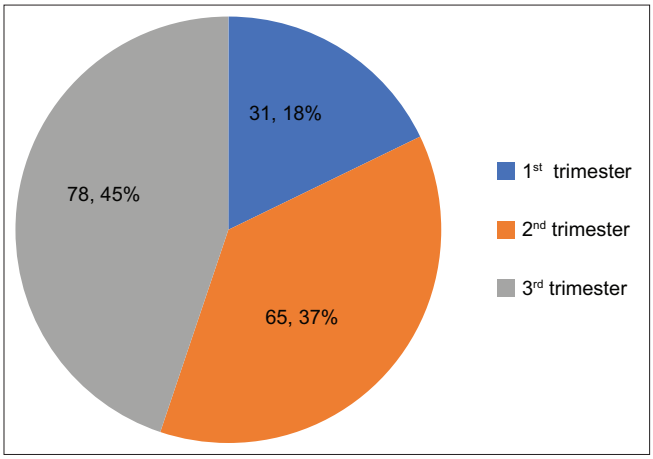

Figure 1: (1) Number of women in the first trimester; (2) Number of women in the second trimester; and (3) Number of women in the third trimester

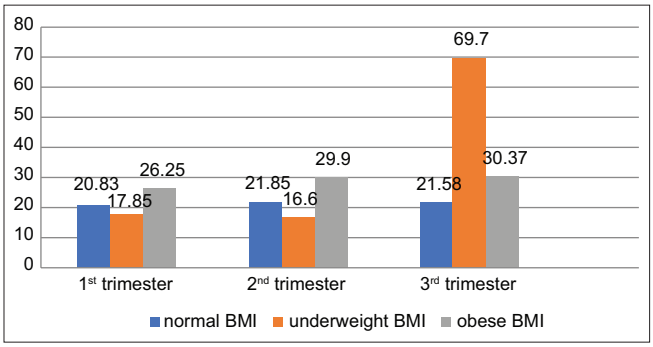

Figure 2: First trimester (Average BMI: normal BMI = 20.83, underweight BMI = 17.85, obese BMI = 26.25, second trimester (Average BMI): normal BMI = 21.85, underweight BMI = 16.6, obese BMI = 29.9, and third trimester (Average BMI): normal BMI = 21.58, underweight BMI = 69.7, obese BMI = 30.37

Table 9: Obese BMI: 25 primigravida women with average (BMI=30.37)

Motions	*R*	*r2*	*P*	*C.I.*
Hip flexion	0.3458	0.1196	0.0567	−0.009803–0.6238
Hip extension	0.1644	0.02701	0.3770	−0.2018–0.4902
Hip abduction	−0.3602	0.1297	0.0465	−0.6337–−0.006620
Hip adduction	0.04796	0.002300	0.7978	−0.3118–0.3957
Hip medial rotation	−0.2762	0.07627	0.1326	−0.5744–0.07627
Hip lateral rotation	−0.5121	0.2622	0.0032	−0.7334–0.1926
Lumbar lateral flexion	−0.08674	0.007524	0.6427	−0.4280–0.2762
Lumbar flexion	−0.5791	0.3353	0.0006	−0.7745–−0.2827
Lumbar extension	−0.06410	0.004109	0.7319	−0.2971–0.4092

*r: Correlation coefficient, C.I.: 95% confidence interval, r2: Coefficient of determination

range of motion of pelvis was measured. Compensatory lumbar spine motions:

1) Anterior pelvic tilt: Lumbar extension and hip flexion
2) Posterior pelvic tilt: Lumbar flexion and hip extension
3) Lateral pelvic tilt: Right lateral flexion (pelvic drop): Left pelvic hike-right hip adduction. For left lateral flexion of spine: Right hip abduction
4) Forward rotation: Lumbar rotation to left: Hip medial rotation
5) Backward rotation: Lumbar rotation to right: Hip lateral rotation
6) Sacroiliac joint nutation: Posterior pelvic tilt
7) Sacroiliac joint counter nutation: Anterior pelvic tilt.

Application of the Goniometer to Assess the Range of Motion

1. Hip flexion: Patient position – supine (lying on back). Goniometer fulcrum – lateral aspect of hip joint greater trochanter as the reference. Goniometer moving arm – lateral midline of femur using lateral epicondyle as reference. Goniometer fixed arm – lateral midline of pelvis. Ask the patient to flex her hip as much as possible keeping the knee joint straight and check for the degree of hip flexion with the help of goniometer. This range will also tell us about the anterior tilt of the pelvis
2. Hip extension: Patient position – prone (lying on chest/stomach) or standing. Goniometer fulcrum – lateral aspect of hip joint, greater trochanter as the reference. Goniometer moving arm – lateral midline of femur using lateral epicondyle as the reference. Goniometer fixed arm – lateral midline of pelvis. Ask the patient to extend her hip as much as possible keeping the knee joint straight and check for the degree of hip extension with the help of goniometer. This range will also tell us about the posterior pelvic tilt.
3. Hip abduction-adduction: Patient position – supine. Goniometer fulcrum – anterior superior iliac spine (ASIS) of pelvis. Goniometer moving arm – anterior midline of femur using patella as the reference. Goniometer fixed arm – line joining both the ASIS. Ask the patient to fully abduct the lower limb and check the range with the help of goniometer, and then ask her to fully adduct her lower limb as much as possible and check for the range with goniometer. This range will also tell us about the lateral pelvic tilt (pelvic hike and drop).
4. Hip medial rotation – lateral rotation: Patient position – sitting with knees flexed at 90°. Goniometer fulcrum – anterior aspect of patella. Goniometer moving arm – anterior midline of lower leg, between the two malleoli as reference. Goniometer fixed arm – perpendicular to the floor. Ask the patient to internally rotate the lower limb and check the range with goniometer later ask her to externally rotate the lower limb as much as possible and check the range with the goniometer. This range will tell us about the forward and backward rotation of the pelvis.
5. Lumbar flexion-extension: Patient position – standing. Goniometer fulcrum – on greater trochanter of femur. Goniometer moving arm – along lateral aspect of pelvis. Goniometer fixed arm – lateral aspect of femur. Ask the patient to flex the lumbar (trunk) as much as possible and then check the range with goniometer. Same ways ask her to extend the trunk and note down the range with the goniometer. This range resembles posterior and anterior tilt of pelvis, respectively.
6. Lumbar lateral flexion: Patient position – standing. Goniometer fulcrum: on S2. Goniometer moving arm: Parallel to spinous process of spine. Goniometer fixed arm: perpendicular to

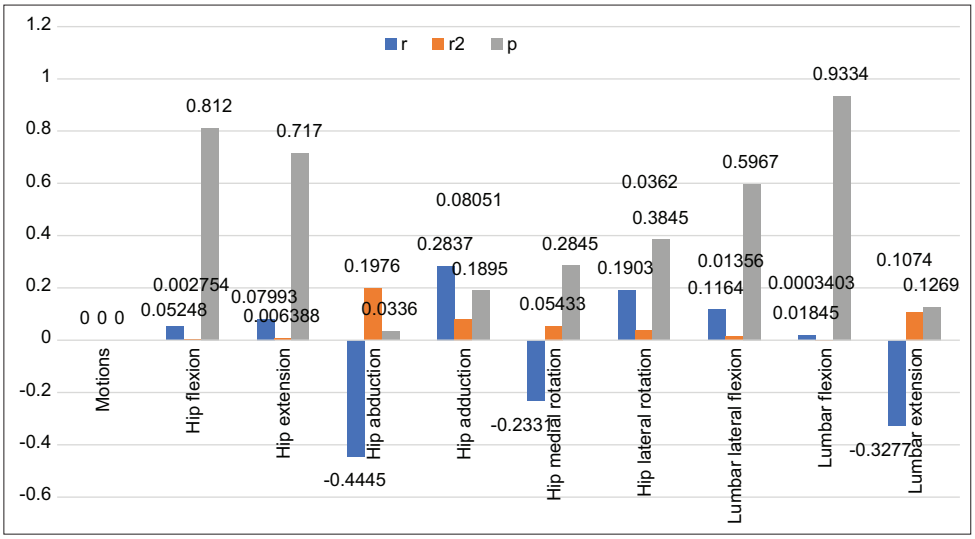

Figure 3: Frist trimester with normal BMI: 23 primigravida women with average BMI= 20.83 and their correlation coefficient (r), coefficient of determination (r2) and *P* value

ground. Ask the patient to laterally flex (bend the trunk) without bending the knees, hips and then measure the range with the goniometer. This resembles lateral pelvic tilt with pelvic hike pelvic drop.

Data Analysis

The primary variables of interest were hip and lumbar range of motions for all three trimesters of pregnancy with the correlation to BMI. Statistics were analyzed using Pearson's correlation test and statistical measures used were correlation coefficient (r), 95% confidence interval (C.I), and coefficient of determination (r2).

Results

The study was conducted among 174 pregnant females, out of which 31 were of the first trimester, 65 were of second trimester, and 78 were of the third trimester [Figure 1]. In case of 1st trimester with average of normal BMI for individuals was 20.83; for average of underweight BMI for individuals was 17.85 and average of obese BMI for individuals was 26.25; for 2nd trimester the average of normal BMI for individuals was 21.85, average of underweight BMI for individuals was 16.6 and average of obese BMI for individuals was 29.9; for 3rd trimester, the average of normal BMI for individuals was 21.58, for average of underweight BMI for individuals was 16.68 and average of obese BMI for individuals was 30.37 [Figure 2]. In this study of kinetics of pelvis, in case of first *trimester*, *P* value for *anterior pelvic tilt* (hip flexion and lumbar extension) is (*P* = 0.8120, 0.1269) for normal BMI [Table 1] which is considered as not significant [Table 2]. *P* value for anterior pelvic tilt with underweight BMI is (*P* = 0.0153, 0.0136) which was considered significant [Table 3]. Moreover, for obese, BMI is (*P* = 0.0493, 0.0493) which is considered as significant. *P* value for *posterior pelvic tilt* (hip extension and lumbar flexion) for normal BMI [Table 1] is (*P* = 0.7170, 0.9334) which is not significant. For underweight, BMI is (*P* = 0.0006, 0.8259) which is extremely significant and not significant, respectively. For obese, BMI is [Table 3] (*P* = 0.2724, 0.3050) which is not significant. In case of *Lateral pelvic tilt* (right lateral flexion) not significant correlation

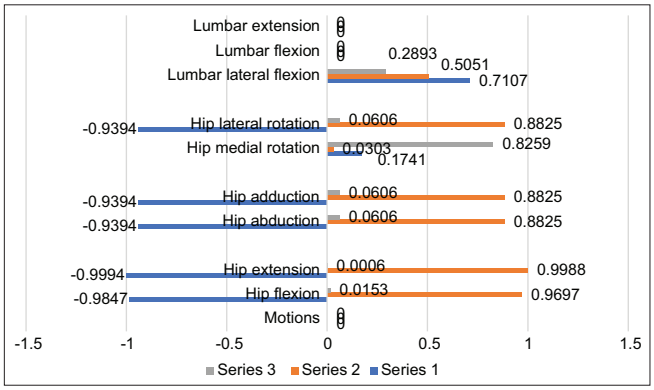

Figure 4: First trimester with underweight BMI: 4 primigravida women with average BMI = 17.85 and their correlation coefficient (r), coefficient of determination (r2) and *P* value

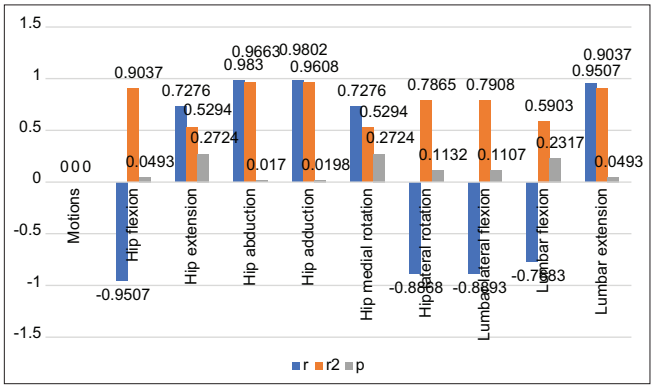

Figure 5: First trimester with obese BMI: 4 primigravida women with average BMI = 26.25 and their correlation coefficient (r), coefficient of determination (r2) and *P* value

results were seen for normal BMI [Table 1] the (p =0.5967), similarly for underweight BMI [Table 2] (p=0.2893) and for obese BMI [Table 3] the (p =0.1107) which is not significant for lateral pelvic

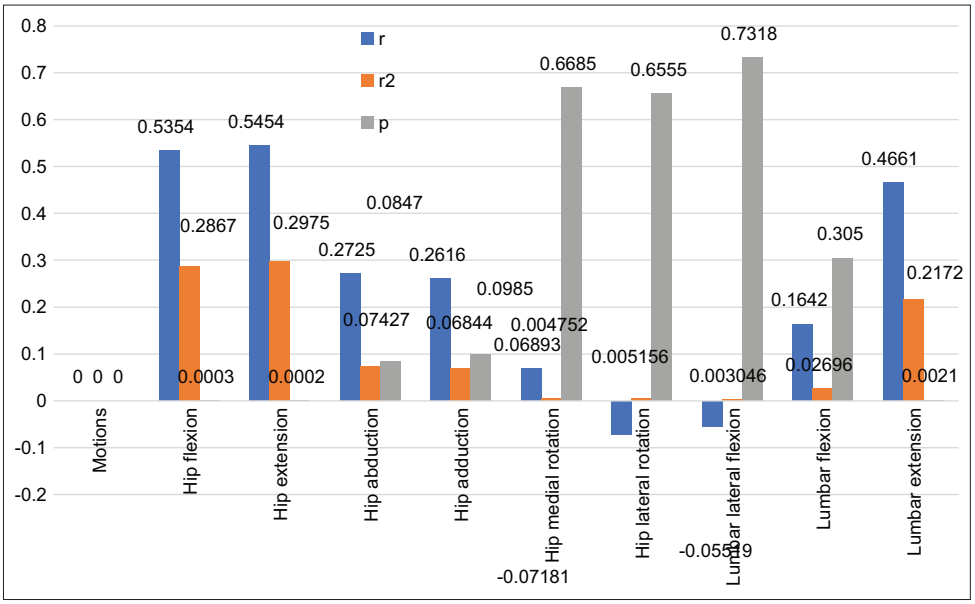

Figure 6: Second trimester with normal BMI: 41 primigravida women with average BMI = 21.85 and their correlation coefficient (r), coefficient of determination (r2) and *P* value

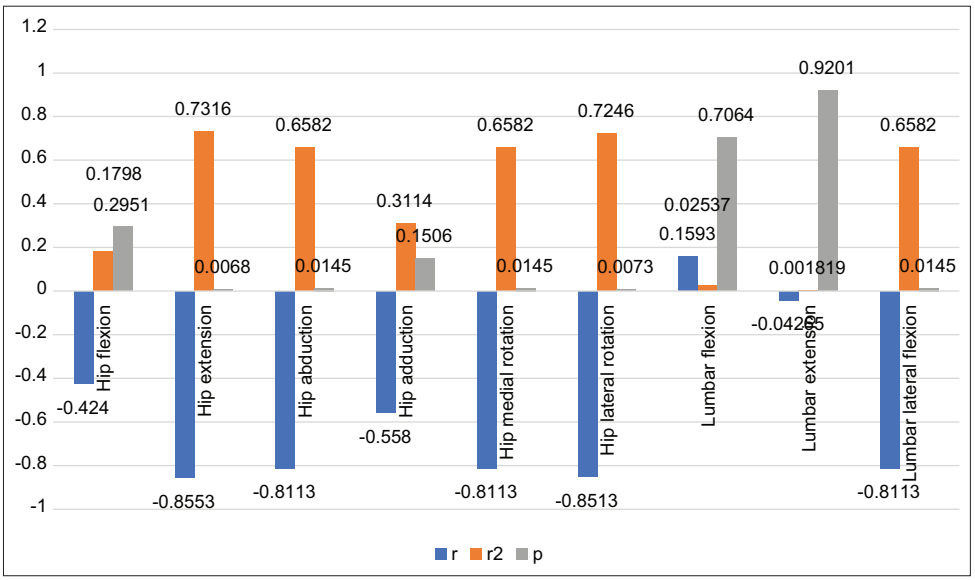

Figure 7: Second trimester with underweight BMI: Underweight BMI: 8 primigravida women with average BMI = 16.6 and their correlation coefficient (r), coefficient of determination (r2) and *P* value

tilt. In case of *Forward rotation*: Lumbar rotation to left i.e. hip medial rotation not significant correlation results were seen for normal BMI [Table 1] with (p=0.2845). Similarly for underweight BMI [Table 2] with (p=0.8259) which is not significant and for obese BMI [Table 3] with (p=0.2724) which is not significant for 7 forward rotation. For underweight, BMI (*P* = 0.8259) which is not significant, and for obese, BMI is (*P* = 0.2724) which is not significant. In case of *Backward rotation*: Lumbar rotation to right i.e. hip lateral rotation not significant correlation results were seen for normal BMI [Table 1] with (p=0.3845), similarly for underweight BMI [Table 2] with (p=0.0606) which is considered significant and for obese BMI [Table 3] with (p=0.1132) which is not significant for backward rotation [Figures 3-5].

In case of 2nd trimester, for normal BMI [Table 4] the p value for anterior pelvic tilt (hip flexion, lumbar extension) is (p=0.0003,0.0021) which is extremely significant and very significant respectively. Similarly for underweight BMI [Table 5] the p value for anterior pelvic tilt (hip flexion, lumbar extension) is (p=0.2951,0.9201) which is not significant and for obese BMI [Table 6] the (p=0.0001,0.3362) which is extremely significant and not significant respectively for anterior pelvic tilt. The p value for posterior pelvic tilt (hip extension, lumbar flexion) for normal BMI [Table 4] is (p=0.0002,0.3050) which is extremely significant and not significant respectively. Similarly for underweight BMI [Table 5] is (p=0.0068,0.7064) which is very significant and not significant respectively and for obese BMI [Table 6] is (p=0.0003,0.9594)

which is extremely significant and not significant respectively for posterior pelvic tilt. In case of Lateral pelvic tilt (right lateral flexion) for normal BMI [Table 4] the (p=0.7318) which is not significant. Similarly for underweight BMI [Table 5] with (p=0.0145) which is very significant and for obese BMI [Table 6] is (p=0.1104) which is not significant for lateral pelvic tilt. In case of Forward rotation: lumbar rotation to left i.e. hip medial rotation the p value for normal BMI [Table 4] is (p=0.6685) which is not significant. Similarly for underweight BMI [Table 5] is (p=0.0145) which is very significant and for obese BMI [Table 6] (p=0.0074) which is very significant for forward rotation. In case of Backward rotation: lumbar rotation to right i.e. hip lateral rotation the p value for normal BMI [Table 4] is (p=0.6555) which is not significant. Similarly for underweight BMI [Table 5] is (p=0.0073) which is very significant and for obese BMI [(Table 6] is (p=0.2616) is not significant for backward rotation. [Figures 6-8].

In case of 3rd trimester, for normal BMI [Table 7] the p value for *anterior pelvic tilt* (hip flexion, lumbar extension) is (p=0.1495,0.0298) which is not significant and significant respectively. Similarly for underweight BMI [Table 8] the (p =0.2314,0.8764) which is not significant and for obese BMI [Table 9] the (p=0.0567,0.7319) which is significant and not significant respectively for anterior pelvic tilt. The p value for *posterior pelvic tilt* (hip extension, lumbar flexion) for normal BMI [Table 7] is (p=0.3021,0.0298) which is not significant and significant respectively. Similarly for underweight BMI [Table 8] is (p=0.9126,0.9126) which is not significant and for obese BMI [Table 9] is (p=0.3770,0.0006) which is not significant and extremely significant respectively for *posterior pelvic tilt*. In case of *Lateral pelvic tilt* (right lateral flexion) for normal BMI [Table 7] the (p =0.2399) which is not significant. Similarly for underweight BMI [Table 8] with (p=0.2137) which is not significant and for obese BMI [Table 9] is (p=0.6427) which is not significant for *lateral*

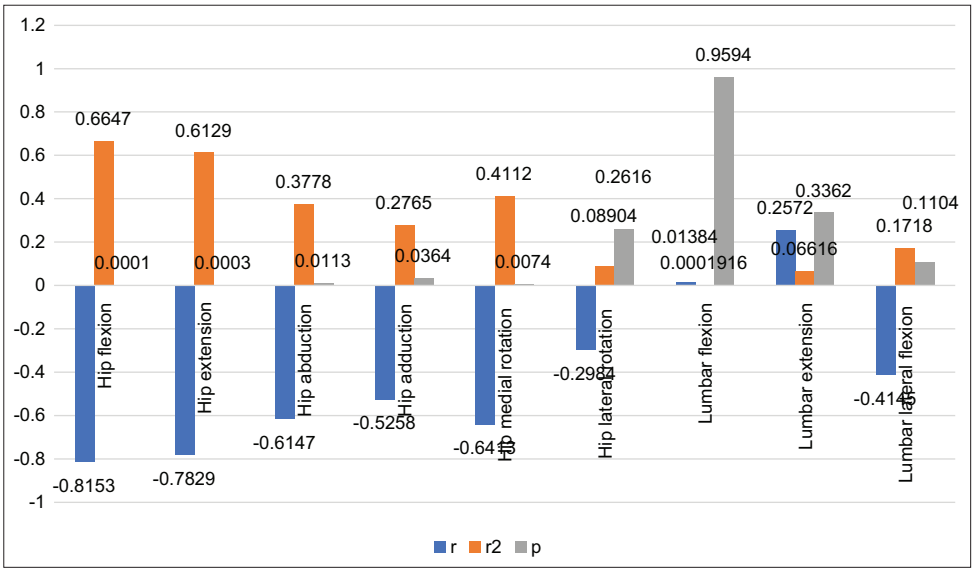

Figure 8: Second trimester with obese BMI: 16 primigravida women with average BMI = 29.9 and their correlation coefficient (r), coefficient of determination (r2) and *P* value

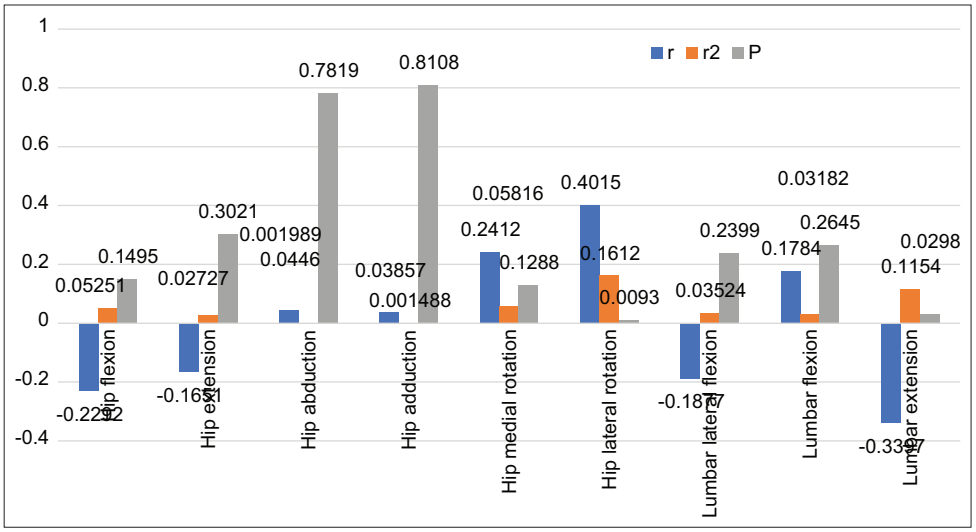

Figure 9: Third trimester with normal BMI: 23 primigravida women with average BMI = 21.58 9 and their correlation coefficient (r), coefficient of determination (r2) and *P* value

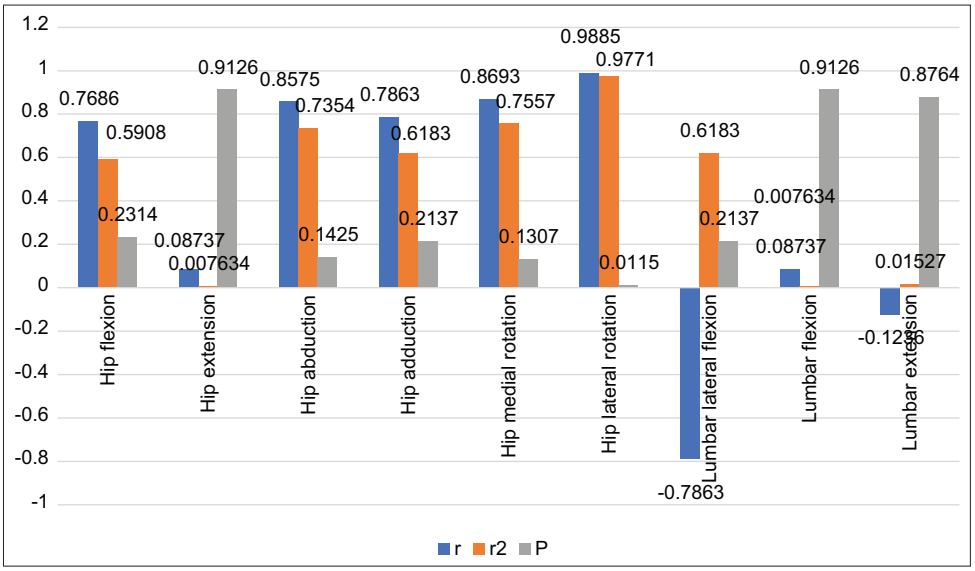

Figure 10: Third trimester with underweight BMI: 4 primigravida women with average BMI = 69.7 and their correlation coefficient (r), coefficient of determination (r2) and *P* value

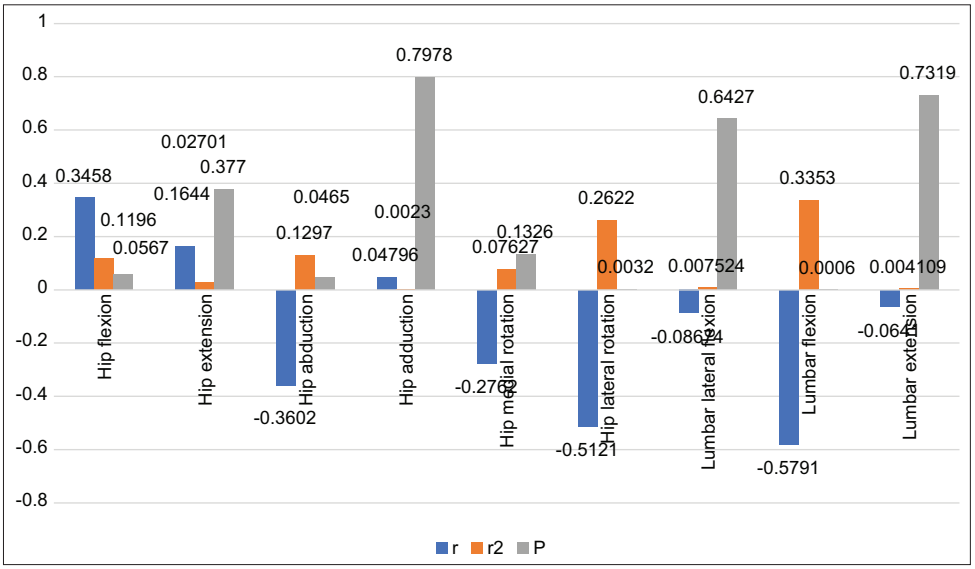

Figure 11: Third trimester with obese BMI: 25 primigravida women with average BMI = 30.37 and their correlation coefficient (r), coefficient of determination (r2) and *P* value

pelvic tilt. In case of *Forward rotation*: lumbar rotation to left i.e. hip medial rotation the p value for normal BMI (Table 7) is (p=0.128) which is not significant. Similarly for underweight BMI (Table 8) is (p=0.1307) which is not significant and for obese BMI (Table 9) is (p=0.1326) which is not significant for forward rotation. In case of *Backward rotation*: lumbar rotation to right i.e. hip lateral rotation the p value for normal BMI [Table 7] is (p=0.0093) which is very significant, similarly for underweight BMI [Table 8] is (p=0.0115) which is significant and for obese BMI [Table 9] is (p=0.0032) which is very significant for backward rotation [Figures 9-11].

Discussion

The study aimed to investigate the linear trends for change in the range of motion of pelvis in all three trimester of pregnancy and its correlation to BMI. In this study, *significant correlation* was seen for the first and third trimesters. *Very significant correlation* was seen for the second trimester and for the third trimester. *Extremely significant correlation* was seen in first trimester, second trimester, and third trimester. This suggests that as the pregnancy progresses, there is slight decrease in range of motion of pelvis. The mean for hip flexion range of motion for first, second, and third trimesters is mean = 68.96, 56.8, and 33.42 suggesting decrease in hip flexion range. The mean for hip extension range of motion for the first, second, and third trimesters is mean = 49, 45.66, and 30.12 suggesting decrease in hip extension range. The mean for hip abduction range of motion for the first, second, third trimesters is mean = 31.45, 29.49, and 13.41 suggesting decrease in hip abduction range. The mean for hip adduction range of motion for the first, second, and third trimesters is mean = 33.45, 26.15, and

21.84 suggesting decrease in hip adduction range. The mean for hip medial rotation range of motion for the first, second, and third trimesters is mean = 39.22, 36.98, and 22.38 suggesting decrease in hip medial rotation. The mean for hip lateral rotation range of motion for the first, second, and third trimesters is mean = 49.74, 40.98, and 22.08 suggesting decrease in hip lateral rotation. The mean for lumbar flexion range of motion for the first, second, and third trimesters are mean = 63.41, 49.76, and 36.35 suggesting decrease in lumbar flexion. The mean for lumbar extension range of motion for the first, second, and third trimesters are mean = 36.77, 38.70, and 18.92 suggesting decrease in lumbar extension. The mean for lumbar lateral flexion range of motion for the first, second, and third trimesters is mean = 29.19, 24.92, and 11.46 suggesting decrease in lumbar lateral flexion. Changes in body composition such as mainly in the morphology and physiology during pregnancy a woman experience.[6] In general, during pregnancy, the weight gain stands at around 11kg,[11-13] although it has been increasing in recent years from 9 kg[14] to 14.5 kg[15] in nonobese women, with much of this gains occurring in the second trimester.[6] The displacement of the center of gravity has been discussed over the years with different statements. As per Foti *et al*.[8] and Rodacki *et al*.,[16] the Center of gravity moves upward and anteriorly, while some other researchers, example Fries and Hellebrandt[17] and Whitcome *et al*.,[18] states that the center of gravity shifts on the upper and posterior direction, results were also shown that when the fetus reaches 40% of the expected final weight; the center of gravity moves anteriorly that this was concluded by the evolution of lumbar lordosis in bipedal hominids. The control of center of gravity along with increased biomechanical costs leads to increase in lordotic adjustments in women.[8] The angular momentum which is caused by rise of moment of inertia of the trunk and later half of pregnancy can be controlled by the reduced range of motion of pelvis in frontal and transverse plane.[10] Few studies have evaluated lower extremity kinetics[8,9,19] in pregnant and most previous work normalized moments to current body mass, potentially underestimating changes in joint demand throughout pregnancy, as the joint itself has not necessarily increased in size or load capacity.[4]

Limitations

The use of EMG could help more in gaining the knowledge of kinesiology of pelvis.

Conclusion

In this study, *significant correlation* was seen for the first–third trimester. *Very significant correlation* was seen for the second trimester and for the third trimester. *Extremely significant correlation* was seen in the first trimester, second trimester, and third trimester. This suggests that as the pregnancy progresses, there is slight decrease in range of motion of pelvis.

References

1. Branco M, Santos-Rocha R, Aguiar L, Vieira F, Veloso A. Kinematic analysis of gait in the second and third trimesters of pregnancy. J Pregnancy 2013;2013:718095.
2. American College of Obstetricians and Gynecologists. Your Pregnancy and Childbirth: Month to Month. 7th ed. Chicago, US: American College of Obstetricians and Gynecologists Women's Health Care Physicians; 2021.
3. Wang TW, Apgar BS. Exercise during pregnancy. Am Fam Physician 1998;57:1846-52.
4. Bagwell JJ, Reynolds N, Walaszek M, Runez H, Lam K, Smith JA, *et al.* Lower extremity kinetics and muscle activation during gait are significantly different during and after pregnancy compared to nulliparous females. Gait Posture 2020;81:33-40.
5. Branco M, Santos-Rocha R, Vieira F. Biomechanics of gait during pregnancy. ScientificWorldJournal 2014;2014:527940.
6. Branco M, Santos-Rocha R, Vieira F, Silva MR, Aguiar L, Veloso AP. Influence of body composition on gait kinetics throughout pregnancy and postpartum period. Scientifica (Cairo) 2016;2016:3921536.
7. Aguiar L, Santos-Rocha R, Vieira F, Branco M, Andrade C, Veloso A. Comparison between overweight due to pregnancy and due to added weight to simulate body mass distribution in pregnancy. Gaitc Posture 2015;42:511-7.
8. Foti T, Davids JR, Bagley A. A biomechanical analysis of gait during pregnancy. J Bone Joint Surg Am 2000;82:625-32.
9. Huang TH, Lin SC, Ho CS, Yu CY, Chou YL. The gait analysis of pregnant women. Biomed Eng Appl Basis Commun 2002;14:67-70.
10. Gilleard WL. Trunk motion and gait characteristics of pregnant women when walking: Report of a longitudinal study with a control group. BMC Pregnancy Childbirth 2013;13:71.
11. Kopp-Hoolihan LE, Van Loan MD, Wong WW, King JC. Fat mass deposition during pregnancy using a four-component model. J Appl Physiol (1985) 1999;87:196-202.
12. Soltani H, Fraser RB. A longitudinal study of maternal anthropometric changes in normal weight, overweight and obese women during pregnancy and postpartum. Br J Nutr 2000;84:95-101.
13. Larciprete G, Valensise H, Vasapollo B, Altomare F, Sorge R, Casalino B, *et al.* Body composition during normal pregnancy: Reference ranges. Acta Diabetol 2003;40:S225-32.
14. Thame M, Trotman H, Osmond C, Fletcher H, Antoine M. Body composition in pregnancies of adolescents and mature women and the relationship to birth anthropometry. Eur J Clin Nutr 2007;61:47-53.
15. Straughen JK, Trudeau S, Misra VK. Changes in adipose tissue distribution during pregnancy in overweight and obese compared with normal weight women. Nutr Diabetes 2013;3:e84.
16. Rodacki CL, Fowler NE, Rodacki AL, Birch K. Stature loss and recovery in pregnant women with and without low back pain. Arch Phys Med Rehabil 2003;84:507-12.
17. Fries EC, Hellebrandt FA. The influence of pregnancy on the location of the center of gravity, postural stability, and body alignment. Am J Obstetr Gynecol 1943;46:374-80.
18. Whitcome KK, Shapiro LJ, Lieberman DE. Fetal load and the evolution of lumbar lordosis in bipedal hominins. Nature 2007;450:1075-8.
19. Branco MA, Santos-Rocha R, Vieira F, Aguiar R, Veloso AP. Three-dimensional kinematic adaptations of gait throughout pregnancy and post-partum. Acta Bioeng Biomech 2016;18:153-62.