Comparative Study to Evaluate the Changes of Pulmonary Function Parameters during Second and Third Trimester of Uncomplicated Pregnancy

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ABSTRACT

The present comparative cross-sectional study was conducted to evaluate pulmonary function parameters in the 2nd and 3rd trimesters of pregnancy and compare the results with those of age - and sex - matched normal non - pregnant subjects. Pulmonary function was assessed in terms of FVC, FEV1, FEV1 / FVC, PEFR, MVV, and FEF25 - 75 %. Each group consisted of 25 participants. After obtaining approval from the Institutional Ethical Committee, this study was conducted by the Department of Physiology in association with the Department of Obstetrics and Gynecology of RG Kar Medical College and Hospital from the period of June-2013 to July - 2014. We found that the age of the control subjects was significantly higher than that in the second and third trimesters of pregnancy. Pregnant women's weight and BMI were considerably higher in the third trimester than those in non-pregnant women. The heart rate, systolic blood pressure, and diastolic blood pressure were comparable between the study and control groups. The mean values of PFT parameters such as FVC and PEFR were lower, whereas FEV1, FEV1 / FVC, and FEF25 – 75 % were higher, but there was no statistically significant difference compared to control subjects, except for MVV, which showed a statistically significant decline in the third trimester of pregnancy compared to non - pregnant women. We infer that despite decreasing abdominal compliance, the preservation of FVC is due to increased rib cage volume displacements, relative thoracic cage mobility, and unaffected diaphragmatic motions. Progesterone, corticosteroids, and relaxin compensate for the mechanical disadvantages of the respiratory system caused by pregnancy.

KEYWORDS
Pulmonary function, trimesters of pregnancy.

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How to Cite This Article:

Supriya Sardar, Indira Ghosh, Ashmita Chakraborty, Mamta Jadon. Comparative study to evaluate the changes of pulmonary function parameters during second and third trimester of uncomplicated pregnancy. J Evid Based Med Healthc 2022; 9(02):1-7.

Received: 22-01-2022;
Manuscript No: JEBMH-22-52202;
Editor assigned: 24-01-2022;
PreQC No. JEBMH-22-52202 (PQ);
Reviewed: 05-02-2022;
QC No. JEBMH-22-52202;
Revised: 09-02-2022;
Manuscript No. JEBMH-22-52202 (R);
Published: 12-02-2022;
DOI:10.18410/jebmh/2022/02.

INTRODUCTION

The most important event in the lives of every woman is giving birth to a child. Numerous physiological, emotional, and physical changes in the body occur throughout pregnancy.[1–3] There are vast and widespread physiological changes that occur during pregnancy, not all of which are visible. These changes include weight gain, cutaneous changes, changes in the breast and genital organs, systemic changes including respiratory and cardiovascular systems, body water metabolism, and hematological and metabolic changes.[4]

Pregnancy is primarily a phenomenon of maternal adaptation to the rising demands of the fetus, and it is one of the greatest instances of selective adaptation in respiratory physiology.[5] Pregnancy-related anatomical, physiological, and biochemical modifications, as well as significant alterations in respiratory physiology, are part of the same process.[6]

Feeling of nausea and vomiting is present in most women[7] in their first trimester, but later, women mostly complain of dyspnea and palpitation due to mechanical discomfort caused by an enlarged gravid uterus. As pregnancy progresses, fetal growth creates a mechanical obstacle to the usual process of maternal breathing.[8] During the due course of pregnancy, the fetus gradually grows, bringing about generalized systemic changes in the mother. This helps the mother accommodate and adapt to the developing fetus's demand.[9] Elevation of the diaphragm occurs due to a cephalad displacement of approximately four–five centimeter and 50 percent widening of the costal angle.[10–12] These changes peak around the 37 weeks of pregnancy and normalize within 6 months after delivery. The chances occur early in pregnancy, before the uterus becomes significantly enlarged.[10,13–15]

The circulatory, respiratory, digestive, renal, endocrine, and metabolic systems play a role in the physiological adaptation of pregnant women. Their detailed understanding enables clinicians to assess the level of adaptability in pregnant women and prevent unnecessary treatment of physiological changes that are misunderstood as abnormal when compared to pre - pregnancy norms.[16] Hormonal changes, rather than the mechanical effect of the enlarged uterus, cause relaxation of the ligamentous attachments of the lower ribs. Rilaxin is the hormone responsible for relaxation of the lower rib cage ligaments.[11] This causes more effect on the respiratory system.

Pulmonary function tests provide a reliable and repeatable evaluation of the functioning condition of the respiratory system as well as the estimation of the severity of lung disorders. Given that all opioids and hypnotics used for such analgesia are respiratory depressants, this information is also necessary to determine if a patient is a candidate for anesthesia, as well as the risks associated with obstetrical analgesia.[15] Pulmonary function test results suggested that lung volume was impaired, including functional residual capacity (FRC), total lung capacity (TLC), and vital capacity (VC).(17,18) Due to the gravid condition of advanced pregnancy, dynamic lung function tests including FVC, FEV1, FEV1 percent, and FEF25 - 75 percent decline.[1,2]

Poor pulmonary function during pregnancy has been linked to poor outcomes. Pulmonary disease can impact pregnancy results, and pulmonary disease can affect pregnancy outcomes.

Preeclampsia, premature birth, and low birth weight are more common in pregnant women with asthma than in those without asthma.[19] There is a clear link between FEV1 during pregnancy and newborn birth weight, according to studies [19,20] and an inverse relationship with intrauterine growth retardation, gestational hypertension, and preterm birth in asthmatic women.[21] Low FEV1 is associated with premature birth in pregnant women with cystic fibrosis [22–24] and increased loss of lung function during pregnancy. As a result, pregnant women with pulmonary illness should frequently have their symptoms and lung function measured by spirometry in order to maintain optimal lung function during pregnancy. As a result, among pregnant women with pulmonary illness, evaluation of pulmonary alterations during pregnancy by spirometry examination in normal pregnancy is critical.

To assess respiratory problems during pregnancy, a thorough understanding of the physiological changes in pulmonary function that occur during a normal pregnancy is required. Based on these considerations and the lack of relevant data on pulmonary function tests in the second and third trimesters of normal pregnant women in Eastern India, we aimed to perform this study. Therefore, the present study aimed to provide pertinent data on physiological changes in lung function during pregnancy and compare the results of lung function parameters between normal pregnant women and normal non-pregnant women.

MATERIALS AND METHODS

This study was conducted by the Department of Physiology Antenatal in Outdoor Clinic, Department of Obstetrics and Gynecology, R. G. Kar Medical College and Hospital, Kolkata. The present cross - sectional study was conducted for duration of 1 year, where selection of the study subjects was performed by convenience sampling from the antenatal clinic of the hospital, and controls were selected from the women who accompanied the pregnant women. Twenty five [25] cases of second trimester pregnant women and 25 third -trimester pregnant women were selected for the study based on inclusion and exclusion criteria. Singleton pregnant women age group 15 - 45 years either primigravidas or multigravidas in the second and third trimesters of pregnancy, were included in the study. Antenatal mothers with known respiratory or cardiovascular disease, anemia, multiple pregnancies, hydramnios, or chronic therapy for any other ailments were excluded from the study. Twenty-five age-matched healthy non - pregnant women who accompanied patients were selected as controls.

The purpose of the study was explained and informed written consent in convenient language was obtained from the participating subjects. The study variables included hemoglobin concentration, postprandial plasma glucose, ABO grouping and Rh - typing, venereal disease research laboratory (VDRL) test, human immunodeficiency virus (HIV), hepatitis b surface antigen (HBsAg), ultrasonography of the fetal profile, and urine for routine examination. Anthropometric parameters such as height and weight were also recorded. General vital parameters, such as pulse rate and blood pressure, were also noted. Body Mass index (BMI) [Normal range 18.50 - 24.99 kg / m2, over weight - > 25.00 kg / m2, obese - > 30.00 kg / m2] BMI was calculated by Queteles index, BMI = Weight (kg) / Height(m2).

Various pulmonary function test parameters [26], such as forced vital capacity (FVC), forced expiratory volume in one second (FEV1), forced mid-expiratory flow (FEF25 - 75 %), FEV1 / FVC ratio, maximum voluntary ventilation (MVV), and peak expiratory flow rate (PEFR), were also measured. Before undertaking the study, institutional ethical committee (IEC) permission was obtained, and all procedures and standardization were performed while performing spirometry as recommended by the American Thoracic Society.[27] The data were compiled using Microsoft Office 2007 Excel software and expressed as mean ± standard deviation (SD). Statistical analysis was performed using the Student's t - test.

RESULTS

A total of 75 study participants were involved in this study. Of these, 50 were pregnant, 25 were allocated to 2nd and 3rd trimester and the remaining 25 were controls. Anthropometric measurements, respiratory rate, arterial blood oxygen saturation, and dynamic pulmonary function tests were performed in all 75 individuals.

Table 1 shows the baseline data of the study population. There was a statistically significant difference in the mean age between the control and second-trimester groups (p = 0.0006) and the control group (p = 0.046). It can also be seen that the weight and BMI of the third trimester group were significantly higher than the second trimester group (p value < 0.0001). Other parameters such as heart rate, systolic blood pressure, and diastolic blood pressure were comparable between the study and control groups.

Table 2 Shows the Mean and standard deviation (S.D) values of forced vital capacity(FVC), predicted value of FVC (Lt), Absolute FEV1 (Lt), predicted FEV1 (Lt), Absolute FEV1 / FVC(%), Predicted FEV1 / FVC(%), Absolute PFER, predicted PFER, absolute FEF25-75% (L / s) and Predicted and FEF25 – 75 % (L / s) of control, 2nd and 3rd trimester of pregnancy. It is seen that the p value for all the parameters in three categories is more than 0.05. This indicates that there is no statistical significant difference of FVC in control, 2nd and third trimester of pregnancy and are comparable.

Table 2 shows the mean and standard deviation (SD) of the absolute value of maximum voluntary ventilation (MVV) in 2nd and 3rd trimester of pregnancy. The differences between the two groups were statistically significant. Also predicated. MVV (L / min) difference in control vs. 2nd trimester and also in 2nd and 3rd trimester was found to be statistically significant.

DISCUSSION

There was a statistically significant difference in the mean age between the control and second-trimester groups (p = 0.0006) and the control group (p = 0.046). The weight and BMI of the third trimester group were significantly higher than those of the second trimester group (p < 0.0001). Therefore, the present study showed a significant increase in the age of the control subjects compared to that of the second - trimester group.

The present study showed that both weight and BMI increased significantly with increasing GA (Table 1), which was attributable to pregnancy.[28] Other studies have also reported similar results[1]. This might be due to the normal weight gain and uterine enlargement that occurs during pregnancy. The heart rate, systolic blood pressure, and diastolic blood pressure were comparable between the study and control groups.

Table - 2 showed that there was decreased in mean value of FVC in second trimester group compared to control and third trimester group but there was increase in mean value of FVC in third trimester compared to control and second trimester group but the values were statistically insignificant. So we found FVC was unchanged statistically during normal pregnancy compared to non-pregnant control group. Previously similar study have concluded that forced spirometry values largely remain unchanged in normal pregnancy compared with a non-pregnant control group.[29–31] A study by Weeerasekara Deepal and workers showed no significant changes in FVC during all trimester of pregnancy.[28] Hormonal alteration in pregnancy causes a reduction in the trachea - bronchial smooth muscle tone and the increasing thoracic writh may be due to enlarging uterus, as a result there is no impairment in large airway function throughout pregnancy.[28] FVC significantly increased in third trimester compared to control and second trimester group in some studies[2] and on the other hand some of the studies showed decrease in FVC.[32,33] The mean value of predicted FVC in second and third trimester was increased but statistically insignificant.

There was an insignificant increase in forced expiratory flow in one second (FEV1) in the second and third trimesters compared to the control group (p value -0.681, p = 0.345, respectively), and an insignificant increase in the third trimester compared to the second trimester group (p = 0.689). Therefore, in our study, Forced Expiratory Volume in one second (FEV1) did not show any significant changes in the second and third trimesters of normal pregnant women compared to non - pregnant women. This indicates that FEV1 was unchanged during pregnancy compared to that in the non - pregnant group. No change in FEV1 was observed in a few studies[32–34], whereas a significant decrease in FEV1 was found in all three trimesters of pregnancy in a study conducted by Batool et al.[35], and a highly significant decline in FEV1 in all trimesters of pregnancy as compared to the control was observed in a study by Jadhav et al.[4] The decrease in FVC was attributable to the mechanical pressure of enlarging gravid uterus, elevating the diaphragm, and restricting the movements of lungs that hamper forceful expiration.

The FEV1 / FVC ratio showed no statistically significant change in the second and third trimesters of pregnancy compared with the control group in our study. In a study by Mokapati et al., FEV1 / FVC was significantly reduced in the third trimester of pregnancy compared to the control (33), while a study by Neeraj et al. showed that there was an increase in FEV1 / FVC.[26]

The peak expiratory flow rate decreased in the second and third trimesters of pregnancy compared with that in the control group, but the values were statistically insignificant. Therefore, our study showed no significant changes in PEFR in the second and third trimesters of normal pregnancy compared to the non-pregnant control group. In our study, PEFR showed a non-significant decline in the second and third trimesters of pregnancy, as previously reported.[36] This decline may be due to increased levels of progesterone in the blood, leading to decreased contraction of the main expiratory muscles[37] and a decline in alveolar Pco2 caused by hyperventilation, which acts as a bronchoconstrictor.[34] However a contradictory finding showing a non-significant increase in PEFR was observed during 1st and 2nd trimester of pregnancy. Brancazio et al.[38]

Variables	Category	Mean	SD	P- Value
Age (yrs)	Control Vs	27.32	6.21	
	2nd trimester	21.96	3.76	**0.006
	Control Vs	27.32	6.21	
	3rd trimester	24.04	5.05	**0.046
	2nd trimester Vs	21.96	3.76	
	3rd trimester	24.04	5.05	0.105
Weight (kg)	Control Vs	50.92	9.71	
	2nd trimester	46.74	4.85	0.06
	Control Vs	50.92	9.71	
	3rd trimester	55	4.56	0.063
	2nd trimester Vs	46.74	4.85	
	3rd trimester	55	4.56	***<0.001
Height (cm)	Control Vs	151.64	7.55	
	2nd trimester	148.96	6.01	0.171
	Control Vs	151.64	7.55	
	3rd trimester	150.2	5.14	0.434
	2nd trimester Vs	148.96	6.01	
	3rd trimester	150.2	5.14	0.436
BMI (kg/m2)	Control Vs	22.32	4.5	
	2nd trimester	21.12	2.48	0.248
	Control Vs	22.32	4.5	
	3rd trimester	24.4	2.19	0.043
	2nd trimester Vs	21.12	2.48	
	3rd trimester	24.4	2.19	***<0.001
Heart rate (beats/min)	Control Vs	78.8	7.37	
	2nd trimester	82.24	5.72	0.071
	Control Vs	78.8	7.37	
	3rd trimester	80.96	8.81	0.351
	2nd trimester Vs	82.24	5.72	
	3rd Trimester	80.96	8.81	0.545
Systolic blood pressure(mmHg)	Control Vs	113.76	10.12	
	2nd trimester	108.04	10.2	0.052
	Control Vs	113.76	10.12	
	3rd Trimester	115.12	10.24	0.638
	2nd trimester Vs	108.04	10.2	
	3rd Trimester	115.12	10.24	0.019
Diastolic blood pressure(mmHg)	Control Vs	69.2	8.98	
	2nd trimester	64.4	13.56	0.146
	Control Vs	69.2	8.98	
	3rd Trimester	70.48	8	0.597
	2nd trimester Vs 3rd Trimester	64.4	13.56	
	3rd Trimester	70.48	8	0.059

Table 1 Baseline Data of Study Population

Variable	Category	Mean	SD	P- Values
Absolute FVC	Control Vs	2.32	0.4	
	2nd trimester	2.16	0.6	0.69
	Control Vs	2.32	0.4	
	3rd trimester	2.18	0.5	0.27
	2nd trimester Vs	2.16	0.6	
	3rd trimester	2.18	0.5	0.9
Predicted valu of FVC	Control Vs	128	24	
	2nd trimester	120	35	0.34
	Control Vs	128	24	
	3rd trimester	117	25	0.13
	2nd trimester Vs	120	35	
	3rd trimester	117	25	0.79
Absolute FEV1	Control Vs	1.83	0.5	
	2nd trimester	1.89	0.5	0.68
	Control Vs	1.83	0.5	
	3rd trimester	1.95	0.4	0.35
	2nd trimester Vs	1.89	0.5	
	3rd trimester	1.95	0.4	0.69
Predicted FEV	Control Vs	125	24	
	2nd trimester	124	34	0.91
	Control Vs	125	24	
	3rd trimester	128	28	0.66
	2nd trimester Vs	124	34	
	3rd trimester	128	28	0.64
Absolute FEV1/FVC (%	Control Vs	85.7	8.1	
	2nd trimester	88.4	8.3	0.46
	Control Vs	85.7	8.1	
	3rd trimester	84	9.4	0.93
	2nd trimester Vs	88.4	8.3	
	3rd trimester	84	9.4	0.19
Predicted FEV1/FVC (%	Control Vs	101	22	
	2nd trimester	104	10	0.46
	Control Vs	101	22	
	3rd trimester	100	11	0.93
	2nd trimester VS	104	10	
	3rd trimester	100	11	0.19
Absolute PFER	Control Vs	4.44	1.1	
	2nd trimester	4.06	1.5	0.3
	Control Vs	4.44	1.1	
	3rd trimester	4.09	1.2	0.29
	2nd trimester Vs	4.06	1.5	
	3rd trimester	4.09	1.2	0.94
Predicted PFE	Control Vs	89.2	29	
	2nd trimester	85.8	31	0.69
	Control Vs	89.2	29	
	3rd trimester	88.7	32	0.95
	2nd trimester Vs	85.8	31	
	3rd trimester	88.7	32	0.75
Absolute MVV(L/min)	Control Vs	60.6	17	
	2nd trimester	57.3	12	0.43
	Control Vs	60.6	17	
	3rd trimester	51	14	*0.0339
	2nd trimester Vs	57.3	12	
	3rd trimester	51	14	0.09
Predicted MVV(L/min	Control Vs	73.2	22	
	2nd trimester	70.8	15	0.67
	Control Vs	73.2	22	
	3rd trimester	60.6	16	*0.0270
	2nd trimester Vs	70.8	15	
	3rd trimester	60.6	16	*0.0237
Absolute FEF25-75%(L/s)	Control Vs	2.21	0.9	
	2nd trimester	2.46	1	0.36
	Control Vs	2.21	0.9	
	3rd trimester	2.27	1	0.82
	2nd trimester Vs	2.46	1	
	3rd trimester	2.27	1	0.49
Predicted FEF25-75%(L/s)	Control Vs	102	37	
	2nd trimester	103	41	0.89
	Control Vs	102	37	
	3rd trimester	102	42	0.98
	2nd trimester Vs	103	41	
	3rd trimester	102	42	0.95

Table 2: Comparison Of Pulmonary Function Tests In 2nd Trimester, 3rd Trimester And Control Groups

Measured PEF longitudinally during pregnancy using a handheld portable flow meter and did not find any change during pregnancy. In another study, no statistically significant difference in PEFR was observed among the three trimesters of pregnancy. PEFR was found to increase progressively with advancing gestational age in a few studies.[39] In contrast, many other studies[2,5,33,36,40] have shown a significant decrease in PEFR during pregnancy compared with the control group. According to studies on PFER by Neeraj et al., PEFR decreased in the third trimester, which was attributed to a drop in alveolar Pco2, which functions as a bronchoconstrictor. Furthermore, the decrease in PEFR may be attributed to the primary expiratory muscles, such as the anterior abdominal wall and internal intercostal muscles, which contract with less force.[26] Sunyal et al. found a drop in PEFR in all trimesters of pregnancy, with a substantial decrease in the second and third trimesters. The mechanical impacts of the larger gravid uterus, which lowers the vertical dimension by restricting the movement of the diaphragm, may be responsible for the progressively lower PEFR score in the three trimesters of pregnancy.[41]

Maximum voluntary ventilation (MVV) min in Table 2, showed that the mean MVV declined in the second and third trimesters in the normal pregnancy group. MVV was significantly lower in the third trimester of pregnancy than in the non-pregnant group (p = -0.0339), and there was an insignificant decline in MVV in the second trimester compared to the control group and in the third trimester compared to the second trimester. The percentage of predicted values showed a significant decline in MVV in third trimester pregnancy compared to the second trimester (p value - 0.0237) and control (p value - 0.027) subjects. A previous study by Teli et al.[2] observed a significant decrease in MVV in all trimesters of pregnancy compared with the control group, with a maximum decrease in the first trimester. In contrast, Monga et al.[32] showed that the progressive decrease in MVV in the third trimester may be attributed to mechanical pressure from the growing gravid uterus, which raises the diaphragm and restricts lung movement, preventing vigorous expiration. This might be related to the bronchoconstriction effect of the lower alveolar Pco2 in the smooth muscles of the bronchial tubes.

When comparing the absolute and percentage of projected values of FEF25 – 75 % in our study to the non - pregnant control group, the mean absolute value declined in the second and third trimesters of pregnancy, although the differences were statistically insignificant. There was a significant decrease in FEF25 – 75 % percent in advanced pregnancy compared to the non - pregnant control group in a previous study. This decrease could be due to a decrease in alveolar Pco2 (caused by hyperventilation), which acts as a bronchoconstrictor[26] and reduces lung volume as pregnancy progresses.[42]

CONCLUSION

When we examined the baseline data of the study population, we discovered that the age of the control subjects was significantly higher than that of pregnant women in the second and third trimesters, and that the weight and BMI of pregnant women in the third trimester were significantly higher than those of non - pregnant women. The study and control groups had similar heart rates, systolic blood pressure, and diastolic blood pressure. Except for MVV, which showed a statistically significant drop in the third trimester when compared with non - pregnant women, pulmonary function test values were statistically unaltered in the second and third trimesters of pregnancy when compared with non - pregnant women. Except for MVV, all readings were within the normal limits.

Our study could not establish our hypothesis that pulmonary function test parameters would be reduced during the advancing gestation of pregnancy compared to non-pregnant women. The mean values of PFT parameters such as FVC and PEFR were lower, whereas FEV1, FEV1 / FVC, and FEF25 – 75 % were higher, but there was no statistically significant difference compared to control subjects, except for MVV, which showed a statistically significant decline in the third trimester of pregnancy in contrast to non - pregnant women. Therefore, the present study suggests that respiratory parameters remain unchanged during pregnancy, except for MVV. As a result, we infer that despite deteriorating abdominal compliance, FVC is maintained due to increased rib cage volume displacements, relative thoracic cage mobility, and unaffected diaphragmatic motions. Progesterone, corticosteroids, and relaxin compensate for the mechanical disadvantages of the respiratory system caused by pregnancy.

The reduction in MVV might be related to the expanding gravid uterus mechanical pressure lifting the diaphragm and limiting lung movement, thus preventing forceful expiration. This might be related to the impact of alveolar Pco2 bronchoconstriction on mechanical smooth muscles.

We believe that further investigations on larger populations are required to establish standards for predicted and desirable PFT levels at various stages of pregnancy, as well as the introduction of a correlation factor when analyzing PFT readings in such individuals. In the absence of these norms of normal deviation from non - gravid states, computerized values obtained through routine spirometry may provide clinicians, obstetricians, and anesthesiologists managing complications in the last trimester of pregnancy with inaccurate information regarding the patient's respiratory status.

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