



Effect of Parity on FVC and FEV₁ during Pregnancy

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Authors' contributions

This study was done by active collaboration between both authors. The study was designed by author AO. The literature review and methodology were done by author VII. The investigations were done by authors AO and VII. The data collected were analyzed by author AO. The discussion was done by both authors.

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ABSTRACT

Background and Aim: The influence of pregnancy on pulmonary function is well documented. However, the parity of the woman is usually not taken into consideration in studying pulmonary function in pregnancy. This study aimed to assess lung function pattern in all trimesters of pregnancy as parity increases.

Study Design: A longitudinal study.

Place and Duration of Study: St Philomena Catholic Hospital, Nigeria between October 2013 and October 2014.

Materials and Methods: The study consists of recording chest circumference, Forced Vital Capacity (FVC) and Forced Expiratory Volume in one sec (FEV₁) in five groups of female subjects with the Primigravida as control, Nullipara, Primipara, Para 2 and Para 3 pregnant women at various trimesters i.e., 13th week, 24th week and 36th week using a tape rule and computerized Spirometer [19] (Spirolab II Italy) respectively. Each group had 40 subjects making a total of 200 subjects for the study.

Results: The study revealed that there was a concomitant increase in FVC and FEV₁ as parity increases. FVC and FEV₁ were significantly increased ($p < 0.001$) in Para 3 when compared to the primigravid control subjects.

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Discussion: The observed improvement in pulmonary function may be due to a progressive increase in the transverse diameter of the chest from a widened subcostal angle. Again, the lumbar lordosis of pregnancy, which is higher in para 3, can explain the increase in chest wall compliance and pulmonary function.

Conclusion: Increased parity favorably affects pulmonary function.

Keywords: FVC; FEV₁; spirometry; parity; pregnancy.

1. INTRODUCTION

Pregnancy is generally a sexually transmitted condition of having a developing fetus [1]. This special state is coupled with physiologic adaptations to care for fetomaternal well-being. The adaptations traverse the respiratory system and others such as the cardiovascular, renal and endocrine systems [2-4]. The respiratory function can readily be assessed by the use of a Spirometer which measures Forced Vital Capacity (FVC), Forced Expiratory Volume in the first second (FEV₁), FEV₁/FVC ratio etc. A spirometer is one of the non-invasive tools used for the study of pulmonary function in humans. Its portability and non-invasiveness ensures cooperation by subjects and thus makes it a veritable tool in assessing lung function. Forced Vital Capacity (FVC), is the largest volume of air that can be expired after a maximal inspiratory effort while the fraction of the vital capacity expired during the first second of a forced expiration is referred to as FEV₁ [5]. However, of the total amount of air that can be blown out in one breath the proportion that can be blown out in one second constitute the FEV₁/FVC ratio [6]. The effect of the pregnancy on the respiratory system is well documented; however, there have been divergent views on findings. For instance, the hormonal changes of pregnancy associated with progressive increase in abdominal volume might have mechanical impact on respiratory function [7]. On the contrary, during pregnancy the increase in the transverse diameter of the chest, resulting from widened subcostal angle, opposes the effect of the enlarging pregnant uterus and elevated diaphragm, maintaining an altered pulmonary function during pregnancy [8]. Vital capacity has also been reported to be minimally increased, decreased or unchanged during pregnancy [9-13]. In addition to pregnancy, other physiologic parameters such as age, sex, weight and height have also been documented to affect pulmonary function [14-16]. There have also been reports that race affects peak expiratory flow rate (PEFR) such that non-

western women show a decrease in peak expiratory flow rate [17] and western women did not show reduced PEFR during pregnancy. Pregnancy is associated with an increase in serum concentration of progesterone and progesterone improves pulmonary function. The cumulative effect of the intermittent exposure of a woman to high levels of progesterone during pregnancy, the progressive expansion of the transverse diameter of the thoracic cage and the attendant laxity of the anterior abdominal wall muscles may have effect on the pulmonary function. However, most of the studies done on pulmonary function in pregnancy did not take into cognizance the parity of the pregnant woman. Parity is the number of a pregnancy a woman has carried to the age of viability i.e. 24 weeks [18]. Thus a primigravida is a woman who is getting pregnant for the first time and a nulliparous woman is one who has been pregnant one or more times but the pregnancy did not get to the age of viability. A primipara is one who has delivered once while para2 and para 3 women are those that have delivered twice or thrice respectively. The anatomical and hormonal changes associated with increasing parity may affect pulmonary function. Thus, the reason for the divergent views in pulmonary function in pregnancy may be due to the effect of parity. This study is therefore aimed at assessing lung function patterns in all trimesters of pregnancy as parity increases.

2. MATERIALS AND METHODS

This longitudinal study involves the recording of chest circumference, FVC and FEV₁ in six groups of female subjects including non-pregnant control, Primigravida, Nullipara, Primipara, Para2 and Para3 pregnant women at various trimesters i.e., 13th week, 24th week and 36th week using a tape rule and computerized Spirometer [19] (Spirolab II Italy) respectively. Ethical clearance was obtained from the ethics and collaboration committee of St. Philomena Catholic Hospital.

2.1 Sample Size

$N = \frac{2(z\alpha + z\beta)^2}{(\delta/\sigma)^2}$; for $\alpha = .05$, $z\alpha = 1.96$;
for $\beta = .20$; $z\beta = 0.84$.

Hence $(z\alpha + z\beta)^2 = (1.96+0.84)^2 = 7.84 \approx 8/0.5^2 = 32$ [20]

However, some subjects who enrolled in the study may drop out due to study protocol and other reasons. To deal with this, 25% more subjects that the sample size accounted for were enrolled. This now amounted to 40 subjects in each group. The groups were non-pregnant Control, Primigravida, Nullipara, Primipara, Para2 and Para 3.

Subjects with at least one of the following; history of cardiopulmonary disease, recent abdominal or chest surgery, recent eye surgery, chest pain or recent heart attack, past history of smoking, any obstetric complication e.g. placenta previa or a co-existing fibroid, bad obstetric history, history of hemorrhoids, pregnancy from assisted reproductive technique, hemoglobin concentration less than 10 mg/dl and previous history of caesarean section was disqualified from the study.

2.2 Measurement of Chest Circumference

The widest diameter of the chest was measured with the aid of a tape rule.

2.3 Measurement of Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV₁)

The test was done after informed consent was obtained from the subjects. Each subject in the sitting position was instructed on the need to put maximum effort at blowing into the digital Spirometer [19] (Spiro Lab II, Italy). The subjects were asked to hold the mouthpiece around the opening of the mouth in such a way that the mouth completely goes tightly around the opening of the mouth piece to prevent leakage of air. Subjects were then asked to inspire maximally and then expire forcibly at once through the mouthpiece into the spirometer. Each subject was to have three trials. Values for each subject were recorded from the screen as the highest of the three. Test results were given as measured values in liters using American Thoracic Society Standardization of Spirometry [21].

2.4 Statistical Analysis of Results

Results were presented as mean \pm standard deviation and line graphs using the Micro Soft Excel 2007 and statistical analysis was done using the paired t test. Values of $p < 0.05$ were considered significant.

3. RESULTS

For the group 1 (Primigravida), all the 40 subjects that started the study were available throughout the three trimesters. For the group 2 (Nullipara), all 40 subjects sampled were maintained from first trimester till the third trimester. For the group 3 (Primipara), the 40 subjects sampled were also maintained from the first trimester till the third trimester. For the group 4 (Para2), of the 40 subjects that started the study in the first trimester, 34 subjects were available in the second trimester. Of the 6 subjects that subjects that were not available, 3 subjects declined as per study protocol while 3 subjects stopped attending antenatal in St Philomena's Catholic Hospital. At third trimester for this group, 33 subjects were available for the study; one had an indication for a caesarean section. For the group 5 (Para3), of the 40 subjects studied in the first trimester, 26 subjects were available in the second trimester, the remaining 14 of the subjects stopped attending antenatal clinic in St Philomena's Catholic Hospital. In the third trimester, only 23 subjects were available for the study, the remaining 3 subjects declined because of study protocol. The bio-anthropometric data of the subjects are presented in Tables 1 and 2.

Table 1. Age and height for control and various parities

| Parity | Age in years | Height in meters |
|----------------------------------|------------------|------------------|
| Primigravida (n=40) (Control) | 24.12 \pm 1.78 | 1.61 \pm 0.06 |
| Nullipara (n=40) | 24.28 \pm 1.84 | 1.59 \pm 0.01 |
| Primipara (n=40) | 25.61 \pm 2.75 | 1.61 \pm 0.04 |
| Para2 (n=40) | 26.03 \pm 3.11 | 1.60 \pm 0.05 |
| Para 3 (n=40) | 29.86 \pm 3.65 | 1.61 \pm 0.07 |

4. DISCUSSION

A well-adapted maternal pulmonary function is essential for the fetomaternal wellbeing and the overall outcome of the high metabolic state of pregnancy. The adaptive changes in respiratory

physiology are due to increasing size of the fetus with advancing gestation which contributes a mechanical impediment to normal process of ventilation [22]. This mechanical impediment is marginal at the beginning of pregnancy and gradually becomes remarkable as pregnancy advanced [23]. In their study they noted that the non-pregnant control Forced Vital Capacity (FVC) was significantly higher than the first,

second and third trimester values due to the impedance effect of the enlarging uterus and engorgement of the upper respiratory tract. To further strengthen this, a study reported that a reduction in FVC is due to the restrictive effect of the enlarging uterus, relative mobility of the thoracic cage and unimpaired diaphragmatic movement of the non-pregnant control subjects [17].

Table 2. Chest circumference (centimeters) in various parities and trimesters of pregnancy

| Parity | 1 st Trimester | 2 nd Trimester | 3 rd Trimester |
|---------------------------------|---------------------------|---------------------------|---------------------------|
| CC_{PG(control)} | n=40 89.11±8.12 | n=40 91.08±4.12 | n=40 93.06±2.89 |
| t value | 0.8239 | 2.431 | 4.046 |
| p value | p>0.05 | p>0.05 | P<0.001 |
| CC_{NP} | n=40 87.13±7.89 | n=40 88.10±4.01 | n=40 90.08±2.78 |
| t value | 1.953 | 1.001 | 0.9420 |
| p value | p>0.05 | p>0.05 | p>0.05 |
| CC_{PP} | n=40 93.07±7.97 | n=40 95.01±4.11 | n=40 97.09±2.43 |
| t value | 1.66 | 3.270 | 4.997 |
| p value | p>0.05 | P<0.05 | P<0.001 |
| CC_{P2} | n=40 91.05±7.89 | n=34 93.01±4.09 | n=33 95.12±2.79 |
| t value | 7.22 | 5.414 | 3.760 |
| p value | P<0.001 | P<0.001 | P<0.01 |
| CC_{P3} | n=40 105.09±7.85 | n=26 108.03±4.12 | n=23 111.11±2.88 |
| t value | 6.133 | 3.448 | 1.307 |
| p value | P<0.001 | P<0.01 | p>0.05 |

CC: Chest Circumference, PG:Primigravida, NP:Nullipara, PP:Primipara, P2: Para 2, P3: Para 3

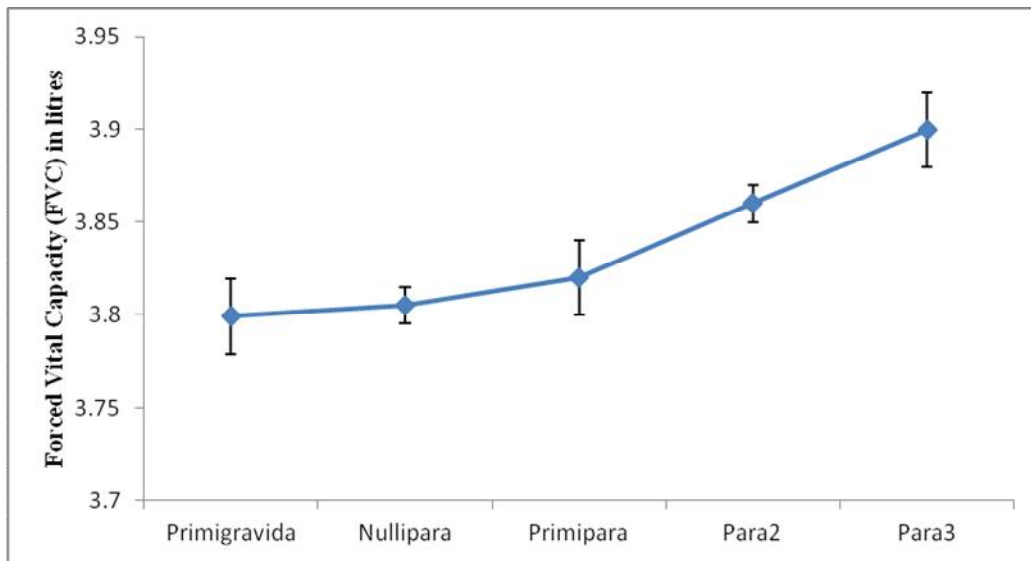


Fig. 1. FVC pattern in the first trimester of pregnancy for primigravid control and other parities
 The FVC was significantly higher ($p<0.001$) in para3 when compared Primigravida. The FVC was essentially same in the Primigravida and Nullipara, it however gradually increased as the parity increased

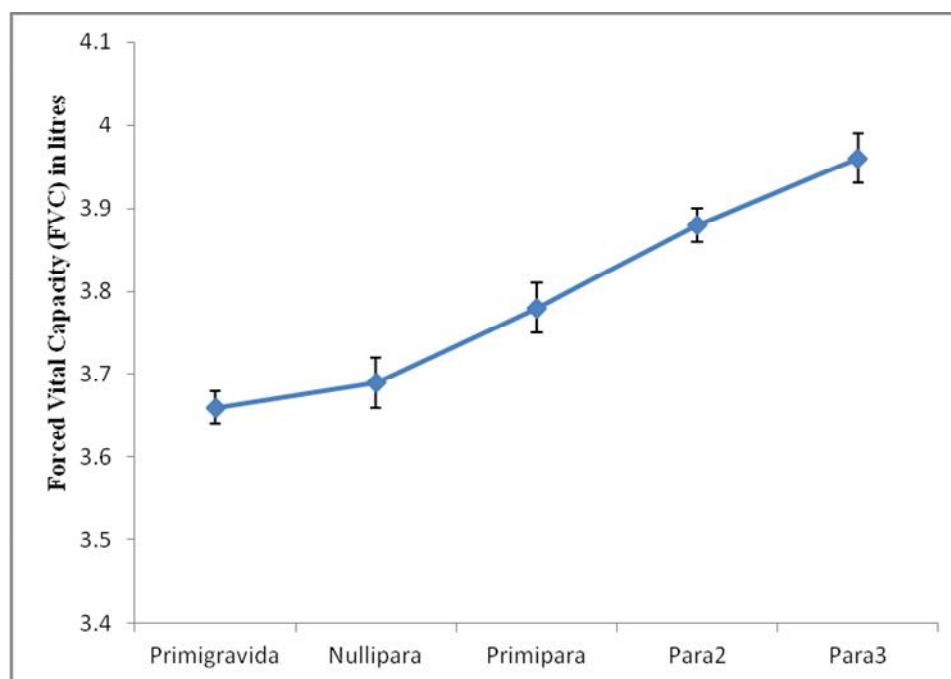


Fig. 2. FVC patterns in the second trimester of pregnancy for primigravid control and other parities

The FVC was significantly higher ($p < 0.001$) in para3 when compared to Primigravida. The FVC in the second trimester was same in Primigravida and Nulliparous but increased in a linear fashion as parity increased

However, the factors for these reductions are not likely to traverse all parities with the same effect. For instance the impaired diaphragmatic movement and the relative immobility of the thoracic cage are more likely to have effect on the primigravida and the nulliparous subjects. This is so because these groups of subjects are likely to have tense anterior abdominal wall and a less compliant thoracic cage because they have not been previously exposed to the stretch of the anterior abdominal wall muscle. This study corroborates this assertion as there was a direct relationship between the pulmonary function and the parity. Para 3 subjects which was the highest parity considered in this study had the highest FVC and FEV₁ and primigravida had the lowest FVC and FEV₁. It was also observed in the study that the FVC and FEV₁ for the nulliparous and primigravid subjects were essentially the same. This strengthens the fact that improved pulmonary function is traceable to increasing parity. In another study, the FVC% was found to be significantly higher in parous compared with the primigravida women, suggesting that the changes in FVC occurring during pregnancy persist post-partum [24]. An epidemiologic study raised the possibility that pregnancy may induce changes in the lung that improve airway function

and persist throughout life [25]. The hormonal activity of pregnancy may have cumulative structural changes in the thoracic width of higher parities which compensates for the rise in the level of diaphragm occurring as a result of the enlarging uterus [26-27]. Progressive relaxation of the ligamentous attachments of the ribs [28-29] cause the subcostal angle of the ribcage to increase from 68° to 103° in early pregnancy before the uterus is substantially enlarged. This progressive relaxation is potentiated in each pregnancy hence the improved pulmonary function in the higher parity. The high serum progesterone level in each pregnancy also brings about the relaxation of smooth muscles [30] and increases β-adrenergic activity [31] with an overall improvement on pulmonary function. The irritability effect of estrogen on the respiratory center synergizes with progesterone to cause hyperventilation. Consequently there is increase in the activity and pressure effect of the abdominal muscles [32-34]. Thus the increase in lung function parameters during pregnancy is traceable to high serum concentration of estrogen and progesterone [35-38]. Furthermore, the production of bronchodilators steroids which improves pulmonary function is increased during pregnancy [39]. The functional anatomy of

lumbar lordosis is less likely to induce thoracic kyphosis, thus giving the rib greater room to expand during inspiration [40]. Lumbar lordosis is a common finding in higher order pregnancy.

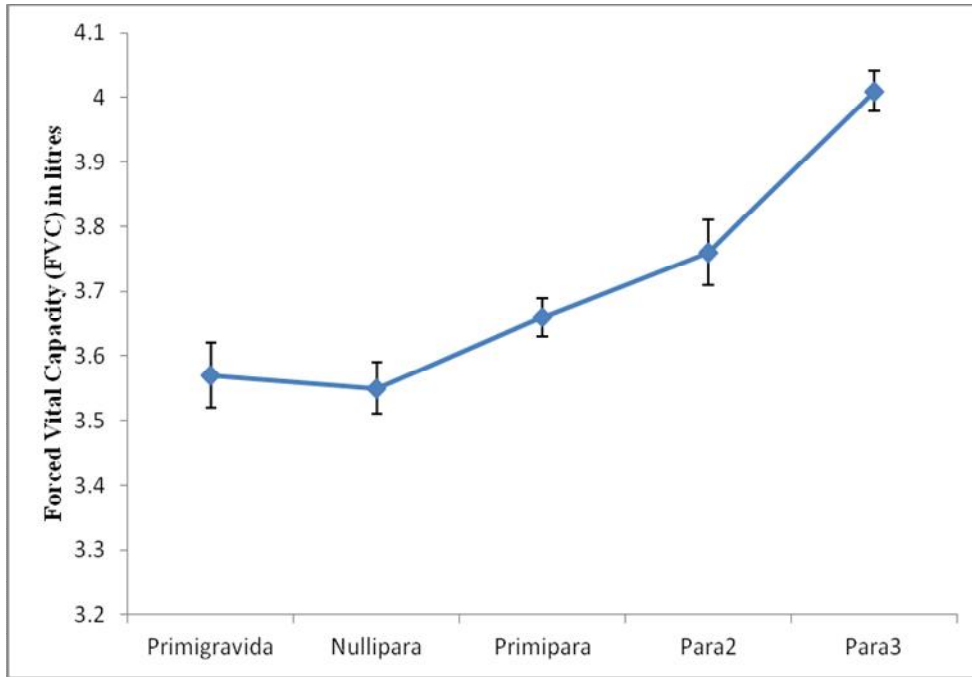


Fig. 3. FVC pattern in the third trimester of pregnancy for primigravid control and other parites
 The FVC was significantly higher ($p < 0.001$) in para3 when compared to Primigravida. The FVC in the third trimester of pregnancy was same in both the Primigravid group of women and the nulliparous group and increased linearly till Para 2 with an upward stroke to Para 3

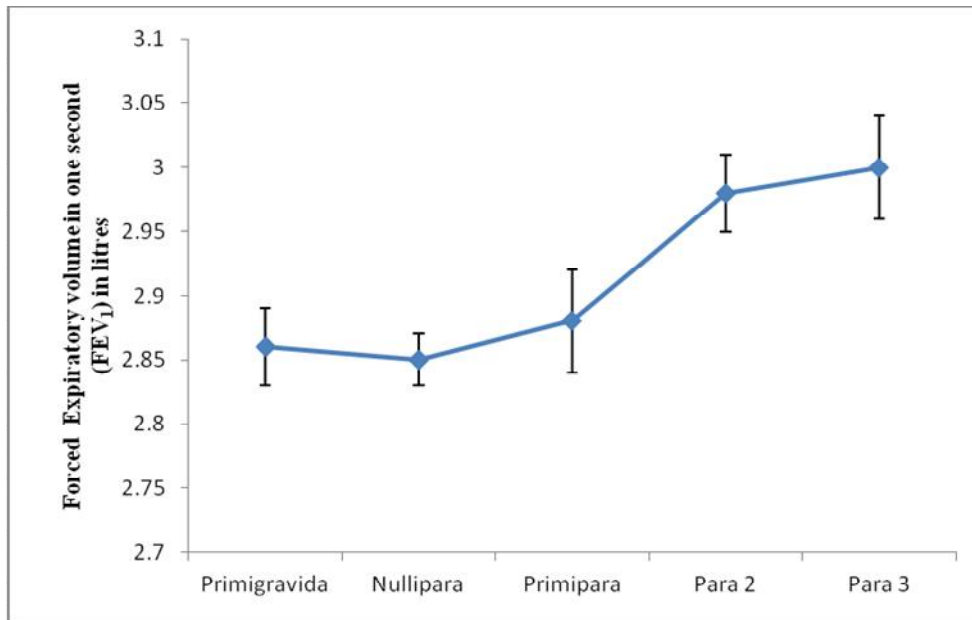


Fig. 4. FEV₁ patterns in the first trimester of pregnancy for primigravid control and other parites
 The FEV₁ was significantly higher ($p < 0.001$) in para3 when compared to Primigravida. The FEV₁ in the Primigravida and Nulliparous groups were essentially the same, however it increased as parity advanced

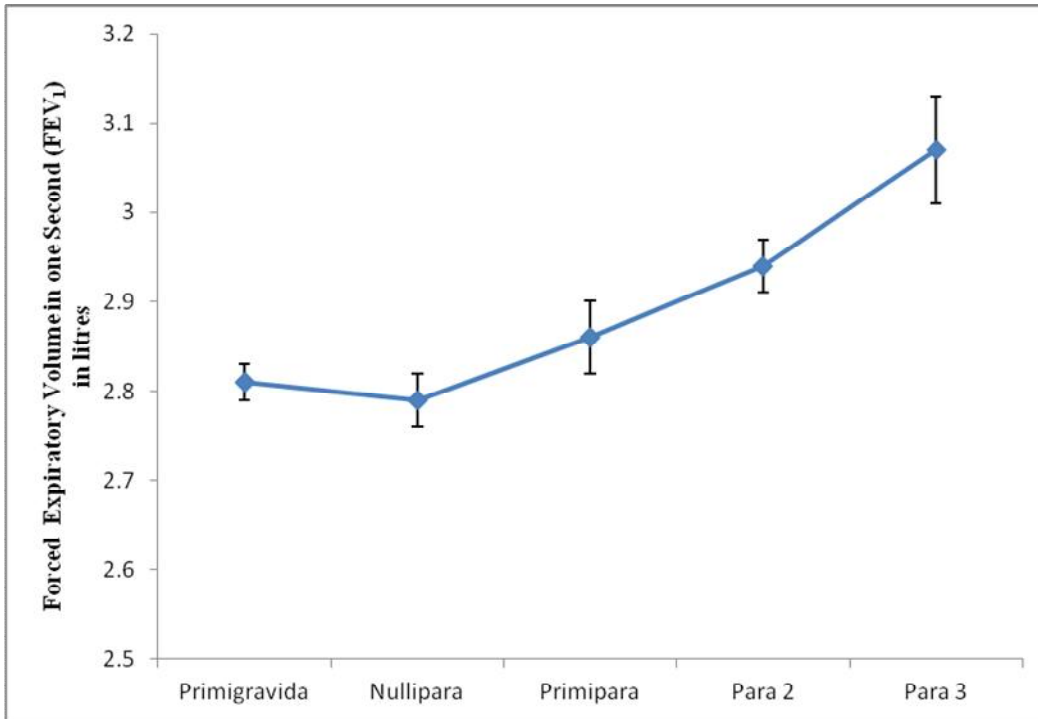


Fig. 5. FEV₁ patterns in the second trimester of Pregnancy for primigravid control and other parites

The FEV₁ was significantly higher ($p < 0.001$) in para3 when compared to Primigravida. The FEV₁ in Primigravida was essentially same as that of the Nulliparous subjects but increased in a linear fashion as parity increased

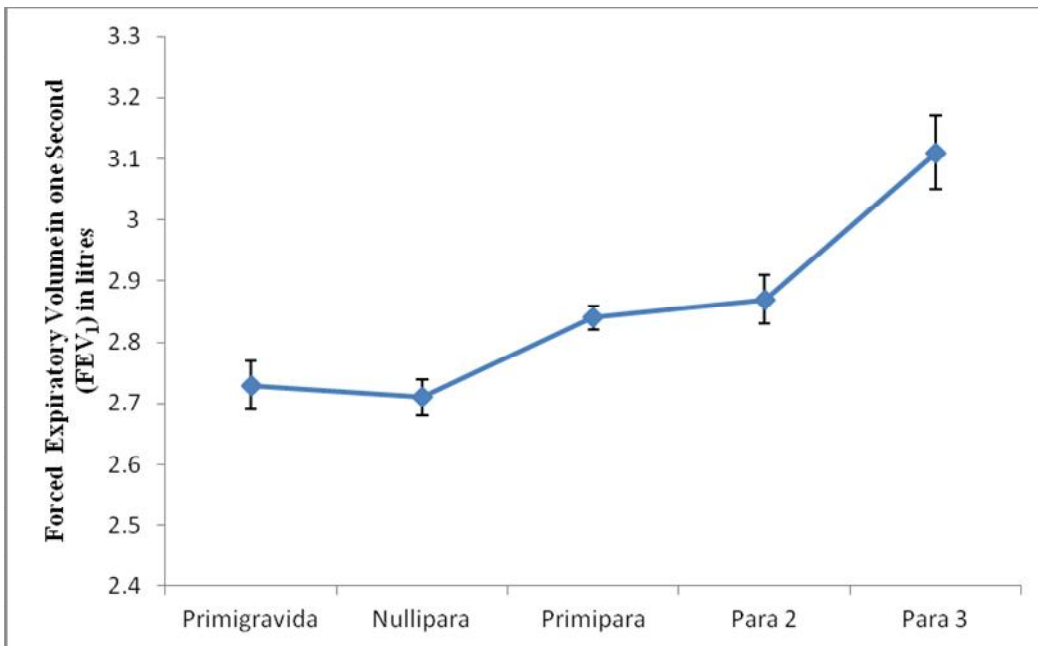


Fig. 6. FEV₁ patterns in the third Trimester of Pregnancy for primigravid control and other parites

The FEV₁ was significantly higher ($p < 0.001$) in para3 when compared to Primigravida. The FEV₁ in the primigravida and nulliparous were essentially the same and increased as the parity increased.

5. CONCLUSION

5.1 Increased Parity Favorably Affects Pulmonary Function

The observed improvement in pulmonary function in higher parities may be due the cumulative effects of progesterone, estrogen and steroids which progressively increase the transverse diameter of the chest from a widened subcostal angle. Again the lumbar lordosis of pregnancy which is higher in Para 3, can explain the increase in chest wall compliance and pulmonary function.

5.2 Limitation

The control subjects were different from the test subjects.

5.3 Future Planning

We would be investigating the effect FVC and FEV₁ on higher parities; para4 and grandmultiparous pregnant women.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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