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Research Article

Pulmonary Function Variations in Different Trimesters of Copperbelt, Zambian Rural and Urban Pregnant Women

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Abstract

Background: Women experience a lot of physical and hormonal changes during pregnancy and the most remarkable aspect of respiratory physiology is the impact that pregnancy has on the function of the lung. Therefore, in order to understand the influence of pregnancy study variations in lung functions on maternal lung functions, we examined the spirometry results of pregnant women in different trimesters.

Methods: A cohort of 1170 healthy pregnant women enrolled in a cross sectional study during the first trimester of their pregnancy was followed up to third trimester. Information pertaining to background characteristics was obtained using a standard questionnaire. Lung function tests were conducted per trimester giving a set of three spirometry results. Lung function parameters of interest included FEV1, FVC and FEV1/FVC. Stata version 13 was used in the data analysis and statistical significance was set at p value 0.05.

Results: Findings showed that almost all the participants (99.4%) had a normal FEV1/FVC ratio. Close to two thirds (60.5%) presented a normal FEV1 and only slightly more than a third (35.6%) participants had a normal FVC. There was a significant mean difference in all the mean LFT parameters (FVC, FEV1 and FEV1/FVC) between rural and urban area. The mean difference between trimesters (Trimester: 1 and 2; 2 and 3 and 1 and3) was also statistically significant (p value < 0.001). Analysis of variance (ANOVA) showed a statistically significant result (p value < 0.001).

Conclusion: Our findings indicate that pregnancy has an impact on maternal lung function outcomes in different trimesters and an updated overview of the respiratory physiology in health pregnant women is important for clinicians to accurately identify and diagnose respiratory abnormalities in pregnant patients.

Keywords: *Spirometry; Respiratory Physiology; Pregnancy; Trimester*

Introduction

There has been a number of reviews of the influence of pregnancy on maternal respiratory system in health and disease over the years [1,2]. A number of studies [3,4] have investigated the impact of advancing pregnancy on the maternal pulmonary function and consistent results show that hormonal changes and the gradual increase in the volume of the abdomen during pregnancy have functional and mechanical influence on the maternal pulmonary function [5].

Reports from previous studies where evaluation of the impact of pregnancy on lung function has been conducted, indicate that pregnancy can affect the course of pulmonary disease and these researchers [6,7] observed that events in pregnancy elicit profound changes in respiratory physiology. According to Patil and Deokar the changes in respiratory physiology are due to increasing size of the fetus with advancing gestation which constitutes a mechanical impediment to normal process of ventilation [8]. This is further supported in a previous [8], study that observed a decrease in FVC and FEV1 with FVC decreasing more than FEV1 such that the FEV1/FVC ratio is seen to be

increased in advancing pregnancy. According to Memon., *et al*. peak expiratory flow rate and their percentage of predicted values were significantly lower during third trimester of pregnancy and it progressively decreased from first to third trimester [9].

However, researchers especially from old epidemiologic studies argue that pregnancy has no significant effect on FEV1 or the FEV1/FVC ratio [10-12]. Peak expiratory flow rates remain close to the normal range and do not change during pregnancy [13]. Other investigators having similar views state that the shape of the flow-volume curve and absolute flow rates at low lung volumes are normal in pregnant women [14,15]. Thus, nonpregnant reference values can be used to evaluate spirometry in pregnant women. They further state that FVC and FEV1 remain unchanged during pregnancy and that if there is any change then it is not due to pregnancy alone. In a study to determine pulmonary function results in the second and third trimester of pregnancy by Deolalikar, 2014 [16], FVC showed a significant decrease in second and third trimester of pregnancy but FEV1 and FEV1/FVC did not show any significant alteration and the researcher observed that the pulmonary functions were largely within range. A relatively recent epidemiologic study has raised the possibility that pregnancy may induce changes in the lung that improve airway function and persist throughout life [17].

Therefore, understanding the respiratory physiology of a pregnant woman is important particularly for clinicians as they assess pregnant patients with pulmonary disease or underlying lung diseases, such as asthma [18,19]. Other researchers have also pointed out the importance of monitoring the pulmonary function using spirometry during pregnancy indicating that pulmonary disease and suboptimal lung function in pregnancy is associated with adverse birth outcomes. The work on impact of pulmonary disease on birth outcomes by Schatz indicates that pregnancies of asthmatic women are more likely to be complicated by pre-eclampsia, preterm birth, and low birth weight compared to pregnancies of women without asthma [19,20]. Other reported adverse birth outcomes include intrauterine growth retardation [20] and gestational hypertension [19] in women with asthma. A direct relationship has been reported between maternal FEV1 during pregnancy and infancy birth weight and an inverse relationship with intrauterine growth retardation.

There is need to appreciate the normal respiratory physiologic changes of pregnancy and work out an updated overview of the respiratory physiology in health pregnant women [21] in order for clinicians to accurately identify and diagnose respiratory abnormalities in pregnant patients. In view of this we conducted this study in order to provide contextualized findings of comparing lung functions of pregnant women in different stages of pregnancy based on operational research results.

Materials and Methods

A cohort of 1170 healthy consenting pregnant women from Ndola and Masaiti, Zambia were enrolled in a cross sectional study during the first trimester of their pregnancy. The participants were followed up from first trimester of pregnancy to the third trimester. Information pertaining to background characteristics was obtained only once at enrollment using a standard questionnaire. However, lung function tests were conducted per trimester.

Pulmonary function tests were performed at least three times for each pregnant woman in a sitting position with closed nostrils using MIR - Spirobank G (Italy) spirometer and with a different mouthpiece for each subject. Demonstration about the test and the way it is conducted was done for the pregnant woman before the test. Spirometry values (FEV1, FVC and FEV1/FVC) values were taken three times and the best result of the three measurements was recorded. This procedure was conducted at enrolment in the first trimester, at second antenatal visit in the second trimester and lastly in the third trimester giving a set of three spirometry results at the end of the pregnancy.

Statistical Analysis

Stata version 13 was used in the data analysis and population variables were analysed descriptively; mean and standard deviations (SD) were used for continuous variables. Frequency and percent were used for the presentation of categorical variables. Independent t test to ascertain mean differences of lung functions between rural and urban area, Bonferroni multiple comparison test to determine mean differences of lung function parameters between trimesters and analysis of variance (ANOVA) to determine whether the variation of lung function parameters in the three trimesters is statistically significant. Statistical significance was set at a p-value of 0.05 according to the Pearson test for significance.

Results

Table 1 presents a summary of the population background characteristics and close to half (46.4%) of the participants were aged below 25years old. Most (92.1%) of the pregnant women were in a marriage relationship with slightly over half (53.4%) having attained secondary education and more than two thirds (69.6%) not employed. The difference in age groups between rural and urban was statistically significant (p value-0.018). Differences in the attainment of various levels of education between rural and urban were statistically significant (p value- < 0.001) with more women having been to primary and secondary level in urban area.

Background characteristics	Total		Rural		Urban		p value
	(n)	%	(n)	%	(n)	%	
Age							
16 - 24	(565)	46.4	(223)	48.9	(337)	48.3	
25 - 34	(509)	43.9	(211)	43.4	(299)	43.5	0.018
35 - 44	(96)	9.7	(47)	7.7	(53)	6.2	
Marital status							
Married	(1067)	92.1	(443)	90.9	(626)	91.2	
Casual/cohabiting	(13)	1.5	(7)	1	(7)	1.1	
Single	(85)	5.8	(54)	7.8	(54)	7.3	0.397
Divorced or Separated	(5)	0.6	(2)	0.3	(2)	0.4	
Education							
Tertiary	(130)	6.4	(31)	12.6	(87)	11.1	
Secondary level	(630)	53.4	(257)	55	(379)	54.6	
Primary level	(351)	33.7	(162)	28.9	(207)	30	< 0.001
Never attended school	(49)	6.4	(31)	3.5	(24)	4.2	
Occupation							
Unemployed	(814)	69.6	(315)	65.5	(489)	71	
Trader	(290)	24.8	(137)	28.5	(162)	23.5	0.111
Farmer	(27)	2.3	(12)	2.5	(15)	2.2	
Office job	(40)	3.4	(41)	3.5	(39)	3.3	

Table 1: *Showing population characteristics of the study participants.*

Mean Lung function test results of the pregnant women in the study population

The summary of mean lung function test results for the pregnant women admitted to the study are presented in table 2. Almost all the pregnant women (99.3%) had an FEV1/FVC higher than 70% and close to two thirds (60.5%) of pregnant women had a normal FEV1 while more than one third (38.4%) recorded mild obstruction. Normal FVC was obtained in 35.6% of pregnant women while mild reduction and moderate reduction was recorded in 37.4% and 26.9% of pregnant women respectively.

	Rural		Urban		Total		Popn estimate
	%	95% CI	%	95% CI	%	95% CI	
FEV1/FVC							
<70	0.4	[0.1 - 1.6]	0.7	[0.3 - 1.7]	0.7	[0.3 - 1.4]	156
70	0.2	[0.0 - 1.4]	0		0.1	[0.0 - 0.3]	12
>70	99.4	[98.2 - 99.8]	99.3	[98.3 - 99.7]	99.3	[98.6 - 99.7]	23,852
Total	100		100		100		24,020
Pearson: Uncorrected $chi^2(2) = 2.1597$							
Design-based F(1.98, 2316.80) = 1.8092 Pr = 0.164							
FEV1							
Moderate Obstruction	0		1.5	[0.8 - 2.6]	1.1	[0.6 - 2.0]	264
Mild Obstruction	34.1	[30.2 - 38.3]	39.8	[36.2 - 43.4]	38.4	[35.5 - 41.3]	9,221
Normal	65.9	[61.7 - 69.8]	58.8	[55.1 - 62.3]	60.5	[57.6 - 63.4]	14,535
Total	100		100		100		24,020
Pearson: Uncorrected $chi^2(2) = 7.7284$							
Design-based F(1.88, 2194.03) = 4.0867 Pr = 0.019							
FVC							
Moderate Reduction	28.1	[24.4 - 32.1]	26.6	[23.4 - 29.9]	26.9	[24.4 - 29.6]	6,468
Mild Reduction	34.7	[30.8 - 38.9]	38.3	[34.8 - 41.9]	37.4	[34.6 - 40.4]	8,994
Normal	37.2	[33.2 - 41.4]	35.1	[31.7 - 38.7]	35.6	[32.8 - 38.5]	8,559
Total	100		100		100		24,020
Pearson: Uncorrected $chi^2(2) = 1.1883$							
Design-based F(2.00, 2335.82) = 0.8335 Pr = 0.435							

Table 2: *Showing proportions of maternal spirometry results in the study population.*

Mean (+SD) for lung functions in rural and urban pregnant women

There was a similar trend in the lung functions both in rural and urban areas. The mean values of the lung functions reduced as the pregnancy moved from one trimester to the next. In the first trimester, the mean FVC for rural area was 82% (SD 7.9) while in the urban area it was 81.8% (SD 7.8) and 81.7% (SD 7.8) for the entire study population. In the second trimester FVC reduced to 78% (SD7.9) in rural and to 77.6 (SD 7.8) in urban and the entire population had 77.9 (SD 7.8). in the third trimester, the FVC reduced even further 68% (SD 7.9), 67% (SD 7.8) and 67.6% (SD 7.8) in the rural, urban and whole study population respectively. Similar trend was observed in FEV1 and FEV1/FVC. Table 3 summarizes the mean lung functions according to trimester for rural, urban and entire study population.

	Rural		Urban		Total	
FVC	**Mean (%)**	**Std. Dev.**	**Mean (%)**	**Std. Dev.**	**Mean**	**Std. Dev.**
Trimester 1	81.22	7.89	81.81	7.81	81.71	7.81
Trimester 2	77.78	7.87	77.63	7.78	77.89	7.79
Trimester 3	67.56	7.85	67.84	7.75	67.56	7.75
FEV1						
Trimester 1	90.11	9.76	89.12	10.33	90.02	10.12
Trimester 2	86.70	9.67	84.62	10.27	85.90	9.81
Trimester 3	76.67	9.69	74.89	10.39	76.03	10.11
FEV1/FVC						
Trimester 1	102.91	14.12	110.01	12.54	106.70	13.71
Trimester 2	99.00	14.08	105.71	12.51	103.06	12.97
Trimester 3	88.93	14.05	96.01	12.49	92.71	13.66

Table 3: *Showing spirometry arithmetic means and std. dev. according to trimester for rural, urban and entire study population.*

Mean differences of LFT parameters between rural and urban areas

Table 4 presents the summary of the mean differences of the lung functions between rural and urban area at 95% confidence interval. The mean FEV1/FVC ration was higher among the women in the urban compared to the ones in the rural area. On the contrally, the rural mean FEV1 was higher than the one observed in the urban and the mean difference was statistically significant in both cases (FEV1/FVC ratio p value <0.0001 and FEV1 p value 0.003). However, the mean difference for the FVC between rural and urban area was not statistically significant (P value 0.374).

Factor	Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]	P-value
FEV1/FVC	Rural	481	96.69	0.64	14.08	95.42	97.95	
	Urban	687	104.2	0.43	11.22	103.4	105.1	
	Combined	1168	101.1	0.38	13.01	100.4	101.9	< 0.0001
	Diff		-7.53	0.74		-8.98	-6.07	
FVC	Rural	481	75.89	0.36	7.857	75.18	76.59	
	Urban	689	75.74	0.3	7.767	75.16	76.32	
	Combined	1170	75.8	0.23	7.801	75.35	76.25	0.374
	Diff		0.149	0.46		-0.76	1.059	
FEV1	Rural	481	84.75	0.44	9.706	83.88	85.62	
	Urban	689	83.07	0.39	10.32	82.3	83.84	
	combined	1170	83.76	0.3	10.1	83.18	84.34	0.003
	diff		1.684	0.6		0.51	2.859	

Table 4: *Showing mean differences of Spirometry results between rural and urban area.*

Bonferroni multiple comparison test

After running a Bonferroni multiple comparison test, the mean difference of FVC at the margin from trimester 1 to trimester 2 was -4 indicating a reduction in trimester 2. Similar findings were found for FEV1 and FEV1/FVC. Mean difference of FVC from trimester 2 to trimester 3 was -10 indicating a further decrease in trimester 3. FEV1 and FEV1/FVC showed a similar result. Mean difference of FVC between trimester 1 and 3 was -14 indicated a higher reduction and this result was similar in other parameters FEV1 and FEV1/FVC. The mean differences in all cases were statistically significant at a p value of < 0.001.

Analysis of variance (ANOVA)

Table 5 presents analysis of variance results to ascertain mean differences of FVC, FEV1 and FEV1/FVC in the three trimesters. Findings indicate a statistically significant mean difference among the three trimesters at a p value of < 0.0001 for all the three parameters.

Analysis of variance (ANOVA)									
	Trimester	**Mean**	**SD**	**Source**	**SS**	**df**	**MS**	**F**	**Prob > F**
	1	106.94	13.66	Between groups	121680.00	2	60840.00	326.22	< 0.0001
FEV1/FVC	2	102.94	13.66	Within groups	654053.44	3507	186.50		
	3	92.94	13.66						
				Total	775733.44	3509	221.07		
	Total	100.94	14.87						
	1	89.76	10.10	Between groups	121680.00	2	60840.00	596.00	< 0.0001
FEV1	2	85.76	10.10	Within groups	357998.97	3507	102.08		
	3	75.76	10.10						
				Total	479678.97	3509	136.70		
	Total	83.76	11.69						
	1	81.80	7.80	Source	SS	df	MS	F	Prob > F
FVC	2	77.80	7.80						
	3	67.81	7.81	Between groups	121480.08	2	60740.04	997.85	< 0.0001
				Within groups	213473.71	3507	60.87		
	Total	75.80	9.77						
				Total	334953.80	3509	95.46		

Table 5: *Showing analysis of variance (ANOVA) of LFTs in three trimesters.*

Discussions

Our study findings show that the mean differences in the FVC, FEV1 and FEV1/FVC between trimesters decreases as the pregnancy progresses from one trimester to the other. The analysis of variance showed a statistically significant mean difference in the three trimesters with the lung functions in the third trimester decreasing more than twice the decrease in the second and third trimester. The results of the current study therefore, indicates that in the first and second trimesters of pregnancy, the lung functions are relatively normal, while in the 3rd trimester the lung function gets compromised with decrease in FVC and FEV1. The FEV1/FVC decrease but it does not decrease beyond the normal lung function standards. This finding is comparable with the findings in several other studies evaluating impact of advancing pregnancy on pulmonary function. A study among Indian women [22] showed similar findings of relatively normal lung functions in the first and second trimester but declined in the third trimester. In a longitudinal study to determine changes in pulmonary function during pregnancy, Grindheim., *et al*. [5] observed that FVC and FVC% increased significantly after 14 - 16 weeks of gestation.

This important finding is further supported by the fact that women in the last trimester are expected to have different peak expiratory flow compared to those in the first and second trimester because the enlarged full term uterus, in later months of pregnancy, causes elevation of diaphragm by 4 cm. The lower ribs flare out resulting in increase in sub costal angle and there is also increase in transverse diameter of the chest [7,13]. Another investigator [9] also observed that peak expiratory flow rate and their predicted percentage values usually become significantly lower in the third trimester of pregnancy and this continues to decrease from first to third trimester. In a study to determine pulmonary function results in the second and third trimester of pregnancy by Deolalikar [16], FVC showed a significant decrease in second and third trimester of pregnancy. FEV1 and FEV1/FVC did not show any significant alteration and observed that the pulmonary functions were largely within range.

Therefore, our findings together with several previous studies' findings point to the fact that women in the last trimester are expected to have different peak expiratory flow compared to those in the first and second trimester.

Conclusion

It is concluded from the study that pulmonary function tests like FVC and FEV1 decreases due to gravid state in advanced pregnancy. The findings also validates the physiological changes in pulmonary function brought by pregnancy and highlights the need to compile expected and accepted alterations in predicted values of FEV1, FVC and FEV1/FVC in comparison with the non-gravid states for accurate diagnosis when faced with pregnant patient for safer outcome of the pregnancy.

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