Original Article

Pulmonary Function Test and Some Cardiovascular Parameters Changes of Healthy Young Women During Different Pregnancy Trimesters

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Abstract

Background: Pregnancy results in a variety of physiological modifications that are accompanied by hormonal changes, and respiratory system may be one of these modifications. Cardiovascular system of women also undergoes several marked physiological and anatomical changes during gestational period. **Objective:** The purpose of this study is to detect the changes that may occur in the most important test of lung functions throughout pregnancy trimesters among healthy women besides the alterations in some cardiovascular parameters including arterial blood pressure and heart rate (HR). **Materials and Methods:** In this analytical cross-sectional study, 72 healthy nonpregnant women and 195 healthy pregnant women of different trimesters who used to attend a private clinic for antenatal care were involved. Respiratory function was assessed by measuring pulmonary function tests including forced vital capacity (FVC), forced expiratory volume at the first second of expiration (FEV1), peak expiratory flow (PEF), and ratio of FEV1 to FVC (FEV1%), using medical spirometer. The cardiovascular parameters were also measured for all participants. **Results:** Categorized groups based on the three trimesters were matching in age, height, and health status, revealed significant variations ($P < 0.05$) in the tests of pulmonary function when compared to control. Moreover, the tests of respiratory function were highly affected in the third trimester. There were no significant differences in arterial blood pressure and HR ($P > 0.05$) between pregnant women in different trimesters of pregnancy and the control group. **Conclusion:** In pregnancy, pulmonary function tests were significantly affected throughout the different trimesters. The third trimester revealed highly significant changes. These changes were attributed to the anatomical and physiological events that may accompany the pregnancy event in healthy cases. However, the physiological events may not work in isolation from the psychological effects that exacerbate the negative impact on lung function. No significant remarkable changes were observed in the arterial blood pressure and HR during the three trimesters of pregnancy.

Keywords: Arterial blood pressure, heart rate, pregnancy, pulmonary function tests, trimester

Introduction

During pregnancy, the body systems of pregnant women undergo dynamic anatomical and physiological alterations. The physiological alterations that take place throughout gestation are widespread in various organ systems of the body of a pregnant woman, including reproductive organs, growth and enlargement of the breast, weight gain, and other alterations in functions of all body systems such as cardiovascular, respiratory, metabolism, and endocrine.[1,2] These normal physiological adjustments are essential for both the pregnant woman and the fetus to meet their requirements due to increased metabolic demands. Physiological changes in the hormonal patterns along with mechanical influences caused by the enlargement of the uterus are the main causes of pulmonary physiologic changes during pregnancy.[3]

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With the progression of pregnancy, the diaphragm position shifts up to 4–5 cm above the normal level as a result of enlargement of the uterus.[3,4] The lungs are slightly squeezed causing a reduction in the space for oxygen exchange resulting in compromising the lung volumes. In addition to changes in the size of a pregnant woman's uterus, physiological alterations in the respiratory system are attributed to gradual elevation in the levels of serum progesterone[5] Circulating levels of progesterone reach the range starting from 25 ng mL^{-1} during the mid of first trimester (T) of pregnancy to 150 ng mL^{-1} during the last weeks of third trimester.[6] The gradual increase in the level of progesterone hormone stimulates the respiratory rate to increase and tidal volume considerably changes from 500 to 700 mL as pregnancy progresses. Total ventilation also undergoes significant changes by upto 40%.[7,8]

High blood pressure is associated with an increased risk of developing heart disease and stroke.[9] Hypertensive disorders (HD) during the peripartum period are life-threatening conditions, these disorders are the most common contributors to maternal complications and perinatal deaths globally.[10,11] Scientific knowledge of the expected physiological alterations in respiratory function and vital signs associated with pregnancy is important for physicians to avoid misdiagnosis of these physiological alterations as health problems. Therefore, this work was undertaken in order to investigate the changes in the tests of pulmonary function during the three trimesters of pregnancy as a primary endpoint as well as to detect some cardiovascular parameter changes such as arterial blood pressure and heart rate (HR) throughout the different trimesters of pregnancy as a secondary endpoint.

Materials and Methods

Participants and study design

A cross-sectional study recruited 195 normal pregnant women who visited a private clinic for antenatal to find out the influence of normal pregnancy on tests of pulmonary function during the three trimesters of pregnancy, with an age range between 25 and 35 years and a control group of 72 healthy nonpregnant women of same age range. Participants were automatically excluded from the current study if they had a history of diabetes mellitus, hypertension, renal diseases, cardiovascular diseases, respiratory diseases, anemia, obesity, multiple pregnancies, cigarette smoking, and alcohol consumption. The specific anthropometric parameters such as weight (kg) and height (cm) were indicated for all participants, and body mass index was calculated.

Methods

Pulmonary function test was performed for recruited women (pregnant and nonpregnant women) using equipment medical spirometer (MIR Spirolab III Diagnostic Spirometer, Roma, Italy). Spirometry test to evaluate lung function was carried out by a specialist physician at the clinic, and the test was conducted for participants in a comfortable sitting position. Measurement and interpretation of the outcomes of pulmonary function were done as stated by the American Thoracic Society Guidelines. The spirometry test was commonly done during morning hours from 9:00 AM to 12:00 PM in a quiet environment to reduce psychological stress. The participants were instructed to inspire the air deeply and then expire forcefully and as quickly as possible via the spirometer mouthpiece, and the nose was clipped to prevent air leak. The basic pulmonary function test parameters such as forced vital capacity (FVC), forced expiratory volume at the first second of expiration (FEV1), percentage of FEV1 (FEV%), and peak expiratory flow (PEF) were measured to collect the data of this study. Each individual test was repeated three times for the participant under the supervision of the physician and the reliable result of the three recorded readings was considered for analysis. The participants' arterial blood pressure and HR were measured at a fixed time between 9:00 AM and 12:00 PM.

Statistical analysis

Data were tabulated in an Excel sheet. Our data are expressed in mean ± standard deviation format. Normality distribution test was carried out and we found the data were abnormally distributed. Therefore, all groups of pregnant women from different trimesters and nonpregnant women were compared using nonparametric Kruskal–Wallis test. *Post hoc* comparison by Dunn's multiple comparison tests using GraphPad Prism 8.0 software (GraphPad Prism Software Inc., San Diego, CA, USA). If the P value < 0.05, the results are regarded as significant.

Ethical approval

The study was carried out between March 2022 and November 2022 after obtaining research ethical clearance from the College of Pharmacy Ethics Committee, University of Basrah (letter no. 1708, dated February 12, 2022) according to the declaration of Helsinki ethical principle and written consent of the recruited women was collected after full explanation about the purpose of research.

Results

Anthropometric characteristics and some cardiovascular parameters of all recruited women in the study are illustrated in Table 1. The table reveals that all groups were with nonsignificant variations in age and height ($P > 0.05$). On the other hand, the comparison in body weight showed some variations represented by the significant increase in third T group ($P < 0.05$). Furthermore, all individuals were free of any clinical issues and comorbidities. No respiratory diseases or problems, no endocrine disorders or diabetes

Table 1: Anthropometric characteristics and cardiovascular parameters of pregnant women and control group, the values are mean ± SD

Parameters	Control $N = 72$ Mean ± SD	First T $N = 59$ Mean ± SD	Second T $N = 72$ Mean ± SD	Third T $N = 64$ Mean±SD	*P* value
Age (years)	30.12±3.4	29.24±2.16	28.57±3.11	29.35±2.58	NS
Weight (kg)	64.25±7.85	65.14±8.13	68.58±7.74	74.35±9.21*	<0.05*
Height (cm)	158.5±4.22	157.4±4.82	158.2±3.75	157.4±3.65	NS
BMI (kg/m^2)	25.12±3.86	25.66±3.56	26.32±3.88	27.68±4.12*	<0.05*
Systolic pressure (mmHg)	120.75±6.15	114.47±6.75	102.50±6.45	128.25±7.12	NS
Diastolic pressure (mmHg)	80.62±3.29	81.23±5.22	76.56±4.51	85.25±5.16	NS
Heart rate (BPM)	73.2±4.11	72.6±3.55	78.3±4.28	75.5±3.36	NS
Comorbidities	No				
Respiratory diseases	No				
Cardiovascular diseases	No				
Hypertension	No				
Diabetes mellitus	No				
Other diseases	No				

*Level of significance $P < 0.05$

Table 2: Pulmonary function tests in control and the different gestational periods, the values are mean ± SD

Pulmonary parameters	Control	First T	Second T	Third T	*P* value C vs. First T	*P* value C vs. Second T	*P* value C vs. Third T	*P* value First T vs. Second T	*P* value First T vs. Third T	*P* value Second T vs. Third T
FEV1	3.27±0.38	2.92±0.58	3.53±0.41	2.83±0.39	<0.01	<0.05	<0.0001	<0.0001	>0.05	<0.0001
FVC	3.87±0.43	3.42±0.65	3.87±0.43	3.52±0.43	<0.001	>0.05	<0.001	<0.001	>0.05	<0.001
FEV1%	84.56±4.57	85.89±10.18	92.22±14.56	80.36±6.48	>0.05	<0.01	<0.05	>0.05	<0.001	<0.0001
PEF	7.76±0.82	8.05±1.38	6.40±1.48	5.57±0.87	>0.05	<0.0001	<0.0001	<0.0001	<0.0001	<0.01

mellitus, and no cardiovascular diseases were observed or reported. All pregnant groups and control group were matched in the important cardiovascular parameters such as systolic blood pressure (SBP), diastolic blood pressure (DBP) and HR, and there were no significant differences in SBP, DBP, and HR ($P > 0.05$) between pregnant women in different trimesters of pregnancy and control group.

Analysis of pulmonary function test results revealed some variations in different studied parameters of pregnant women throughout different gestational periods as viewed in Table 2. Regarding FEV1, we found a high significant decline in third T group when compared to second T group ($P < 0.0001$) and control group ($P < 0.0001$). Another distinct result that we found was the highly significant decline in first T group and no significant difference between the first T and the third T groups, as illustrated in Figure 1A.

The other measured parameter is FVC that revealed the same profile, third T group had a highly significant decline compared to second T of the pregnancy group ($P < 0.001$) and in comparison to the control group ($P < 0.001$). The first T group also showed a highly significant decline in comparison to the control group ($P < 0.001$) and second T group ($P < 0.001$). Whereas second T group showed a nonsignificant difference compared to the control group ($P > 0.05$), as illustrated in Figure 1B.

The ratio of FEV1 to FVC (FEV1%) revealed a highly significant decline in third T group compared with second T group ($P < 0.0001$) and first T group ($P < 0.001$). Furthermore, FEV1% was significantly different in third T compared to the control group ($P < 0.05$) as seen in Figure 1C. On the other hand, we found no significant change between second T group and first T group as well as no significant change between first T group and the control group ($P > 0.05$).

Figure 1D reveals that PEF had a highly significant decline in third T group compared to both and first T ($P < 0.0001$) and control ($P < 0.0001$) groups, as well as statistical analysis revealed that a significant change between second T and third T groups ($P < 0.01$), whereasthe difference was a nonsignificant between first T group and control ($P > 0.05$).

Discussion

All groups in the present study were with nonsignificant variations in age and height. On the other hand, the comparison in body weight showed some variations

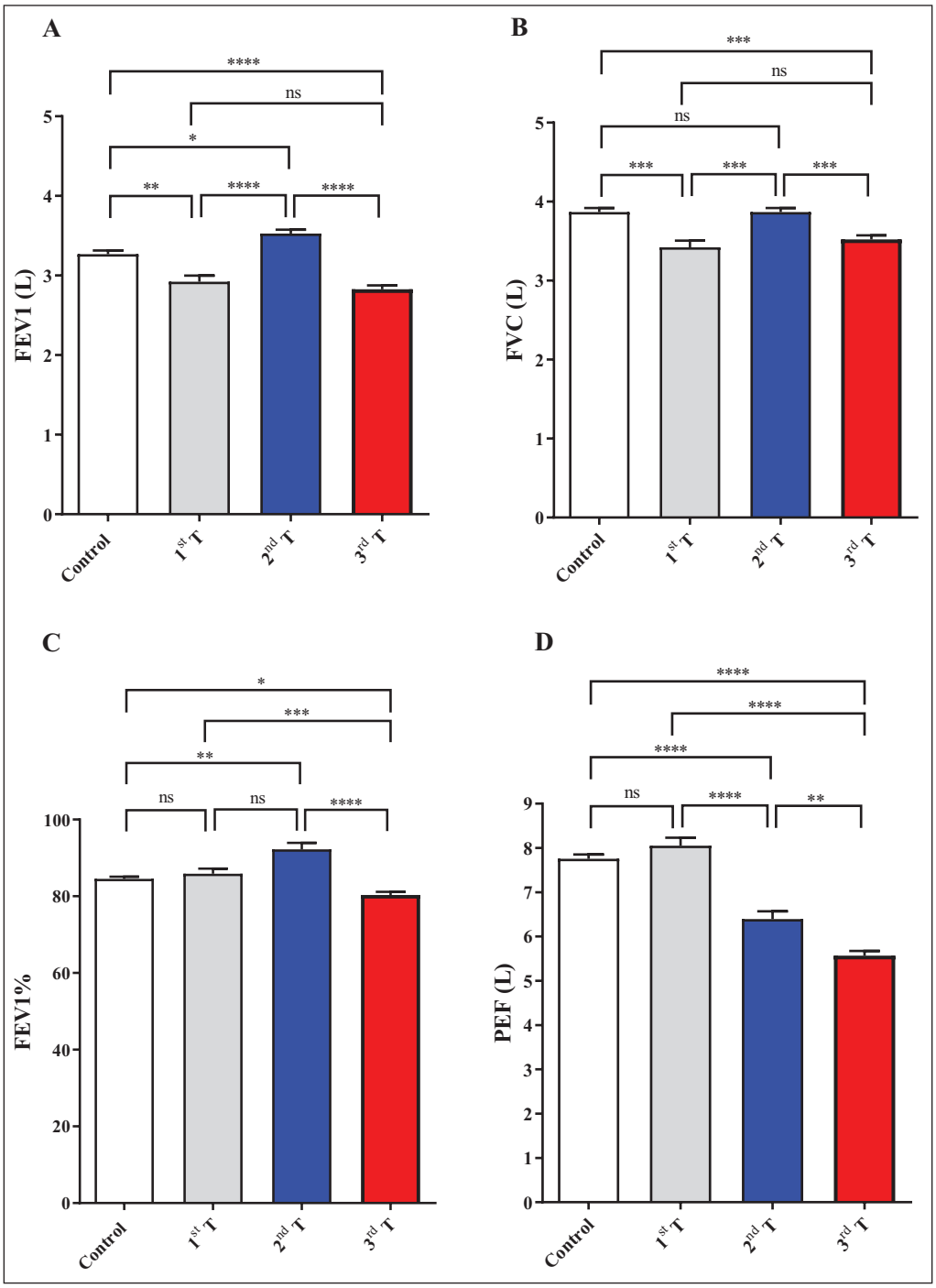

Figure 1: Pulmonary function tests of pregnant and nonpregnant women. (A) Forced expiratory volume at the first second of expiration in control and different gestational periods. (B) Forced vital capacity in control and different gestational periods. (C) The ratio of FEV1/FVC in control and different gestational periods. (D) Peak expiratory flow in control and different gestational periods. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, **** $P < 0.0001$

represented by the significant increase in third T group. Furthermore, all individuals were free of any clinical issues and comorbidities. No respiratory diseases, no endocrine disorders, and diabetes mellitus as well as no cardiovascular diseases were observed or reported. All pregnant groups and control group matched in the important cardiovascular parameters such as SBP, DBP, and HR. Although arterial blood pressure may decline in both first and second trimesters but may increase again to the level of nonpregnant in the third trimester,[12,13] besides the fact that a decrease in peripheral vascular resistance occurs during the first trimester, activating the sympathetic nervous system and raising HR. Accordingly, the rise in cardiac output in the first trimester is caused by a decrease in afterload rather than the previously thought to be a change in stroke volume. The gravid uterus' growing size

compresses the vena cava throughout the third trimester, and the high blood flow to the uteroplacental circulation at this time works to reduce preload, which could lower cardiac output in the third trimester, but this event is offset by the increase in the resting HR.[14]

Data analysis revealed that matching in age is an important factor when measuring pulmonary function tests. It was well established that the respiratory system may undergo various physiological, anatomical, and immunological alterations with aging.[15] Age-related decreases in the strength of respiratory muscles might create difficulties in effective cough, the crucial factor for clearing the airways. At the point when an individual is 20–25 years old, the lungs are completely grown, and as they age, the lung functions decrease gradually. Age-related changes in alveolar dead space alter arterial oxygenation without increasing CO_2 removal. Age-related functional alterations in the airway receptors make them less likely to respond to medications used to treat the same diseases in younger patients.[16] Moreover, all groups were matching in height in the current study. In fact, the reference values of lung functions are typically based on several anthropometric factors, like age, sex, weight, and height. The means of FEV1 and FVC decrease with age, whereas lung volumes and capacities, including residual volume (RV) and functional residual capacity, may be elevated. Each of total lung capacity, vital capacity, RV, FEV1, and FVC are affected by height because they are correlated to the size of the body.[17]

Regarding body weight, it was significantly increased, particularly in the third T group. In pregnant women, gain of some weight is a normal condition during pregnancy, especially during the last trimester of the pregnancy for many factors such as the growth of the baby and the pregnant body developing some extra body tissues. The body will gain weight for a number of causes, including the expansion of the uterus, the placenta, the enlargement of the breasts, and the production of extra blood and fluid retention.[18] In general, the gain in weight was within the recommended range (74.35 ± 9.21 vs. 63.25 ± 7.85) for both control and pregnant participants and it was a natural result of pregnancy. Ideal weight gain during pregnancy is between 11.5 and 16 kg, with 1–1.5 kg gained in the first trimester, after that 1.5–2 kg every month up to the time of delivery.[19] Obese pregnant women were excluded from this study since obesity negatively affects lung function.[20]

Concerning the FVC and FEV1 mean values, it is clear that there were variations along the gestational periods but these parameters were highly affected in the third T group, despite the presence of a distinct result related to the high decline in the first T. The change in pulmonary function tests, particularly in FEV1, FVC, and FEV1%, has been reported in several studies.[21-23] The reason behind these changes is that pregnancy may mark several modifications in the anatomical structure, physiological processes, and biochemical profiles. The main anatomical modifications related to the thoracic cage during pregnancy term are enlargement of thoracic circumference, movement of the diaphragm muscle toward the chest, and 50% elevation in the costal angle.[24,25] Alteration in the thorax, respiratory mechanism, and air passages may affect pulmonary function.

In this work, we observed that there were significant changes in FEV1, FVC, FEV1%, and PEF in different trimesters compared to the control and these changes were highly increasing in the last trimester. It has been concluded by a prior study that negative changes in respiratory function were increasing with the progression of the gestational period.[21] Previous studies have stated that in the course of pregnancy, the physiological changes in hormonal profiles are the major factor of ventilatory alterations in pulmonary function. Progesterone hormone progressively rises throughout the pregnancy and the level of circulating hormone increases from 25 ng mL^{-1} at 6 weeks to 150 ng mL^{-1} at 37 weeks.[26,27] Sensitivity of the respiratory center to PCO_2 is significantly increased as a result action of the progesterone hormone, which triggers the medullary respiratory center. Moreover, estrogen, which is a modulator of progesterone receptors, surged during the normal pregnancy term. Prostaglandins may provoke myometrium during labor and these compounds are usually present throughout the pregnancy term, increasing the amount and availability of specific progesterone receptors, particularly in both hypothalamus gland and medulla oblongata, the central neural areas that are controlling of respiration. Prostaglandin F2 causes the bronchial smooth muscles to contract, increasing airway resistance. On the other hand, several previous studies have pointed to that throughout the period of pregnancy, spirometry results remain within normal limits, with FVC, FEV1, and PEF unaltered or modestly increasing with unaltered FEV1/FVC[27-29] because variations in connective tissue elasticity and tonic contraction of smooth muscle brought on by hormones may mechanically modulate the respiratory system.[21]

It is important to mention that distinct results related to the significant changes in both FEV1 and FVC during the first trimester might be attributed to the psychological effect of the pregnancy. Pregnancy is an event that involves several physical and psychological changes. However, pregnancy can also be a significant stressor. It is always associated with changes in the psychological status of pregnant women. It is usually associated with frequent mood swings and emotions ranging from anxiety, tiredness, lethargy, and sleepiness to excitation.[30] Moreover, some psychological events such as anxiety and panic symptoms were reported to be highly related to develop asthma-like symptoms.[31] Prior studies between the healthy individual group and asthmatic patients or patients with chronic obstructive pulmonary diseases have

revealed that regardless of pulmonary status, individuals who have personalities characterized by a high level of negative emotionality develop more symptoms like dyspnea or respiratory disorders than individuals with less negative emotionality.[32,33]

Conclusion

In pregnancy, pulmonary function tests were significantly affected throughout the different trimesters. The third trimester revealed highly significant changes. These changes were attributed to the anatomical and physiological events that may accompany the pregnancy event in healthy cases. However, the physiological events may not work in isolation from the psychological effects, that exacerbate the negative impact on lung function. No significant changes were observed in the HR and blood pressure among the pregnant women during different trimesters of pregnancy.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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