Comparative pulmonary function test parameters in non-tribal and tribal women in singleton first, second, and the third trimester of pregnancy

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ABSTRACT

Background: During pregnancy, women undergo adaptive changes in different organ systems including the respiratory system by hormonal changes and mechanical pressures. Several previous studies reported the change in pulmonary functions in pregnancy and tribal populations. However, trimester-wise, pulmonary functions in tribal women residing in Jharkhand, India, are not available. Aim: This study aimed to find and compare the pulmonary function test parameters in tribal and non-tribal women in singleton first, second, and third trimesters of pregnancy. Methods: We conducted this cross-sectional observational study in a tertiary care hospital in Jharkhand, India, with 58 tribal women and 116 age-matched controls. The pulmonary function tests, namely forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), maximal mid expiratory flow (MMEF) were measured with a computerized spirometer (Spiro Excel, Medictas, Punjab, India) and FEV1/FVC was calculated. Results: A total of 58 tribal women with median age 22 (Q1–Q3: 21–25) years and 116 non-tribal women with median age 22 (20–25) (P=0.33) participated in the study. The tribal women showed higher respiratory rate (20 [18–24.5] vs. 16 [15–18] per minute, P<.0001), higher MMEF in the first trimester (1.46 [1.12–1.79] vs. 1.24 [1.04–1.5] L/s, P=0.047) and higher PEFR (4.02 [2.78–4.11] vs. 3.15 [2.58–3.87] L/s, P=0.047) in the second trimester. There was no difference in the third trimester of pregnancy. In the overall sample, the tribal women showed higher PEFR (3.82 [2.96–4.33] vs. 3.3 [2.73–4.05] L/s, P=.02) and MMEF (1.43 [0.99–1.7] vs. 1.21 [1–1.47] L/s, P=.04). Conclusion: The respiratory rate was higher in the tribal women in the three trimesters of singleton pregnancy compared to the non-tribal women. There was a higher MMEF in the first trimester and PEFR in the second-trimester pregnancy in the tribal women. The finding of this pilot study should be enhanced by further study with a large number of tribal women from this region.

Keywords: Forced expiratory volume, India, peak expiratory flow rate, pregnancy, respiratory rate, tribal population, vital capacity

Introduction

Pregnancy causes profound adaptive changes not only in the genital organs but also in the cardiovascular system, fluid volume, respiration, fuel metabolism, and nutrition to meet the increasing demands of the growing fetus.¹ The effect on respiration may be influenced by both mechanical and hormonal factors.²
During pregnancy, the equilibrium of various hormones and hormone-like substances is changed in comparison to the non-pregnancy state. This includes progesterone, estrogen, corticosteroid, prostaglandins, and cyclic nucleotide.[3] There may be mechanical and physiological changes in the respiratory system due to this new hormonal state.[4] Furthermore, an increase in the abdominal volume may have mechanical and physiological effects on respiratory performance. However, the rise in transverse chest width, which is caused by a widening of the subcostal angle, counteracts the impact of the expanding pregnant uterus and higher diaphragm, leaving the pulmonary function changed but not impaired.[3]

Socio-religious and cultural beliefs of the tribal population are different from the general population. Being underprivileged, they have limited access to healthcare facilities.[6] The tribal people suffer from undernutrition due to numerous causes which have a detrimental effect on their health condition.[7, 8] Pulmonary function test (PFT) changes with ethnicity and geographic region.[9] A few studies on tribes of India have shown ethnic differences within tribal communities based on their health and nutritional parameters.[10, 11] However, there was no study conducted to observe the pulmonary functions among the tribal women in the three trimesters of pregnancy.

With this background, we conducted this study to observe the pulmonary functions in tribal women in three trimesters of singleton pregnancy and compared it with age-matched and gestational age-matched non-tribal control. The knowledge of the pulmonary functions in the three trimesters of pregnancy in the tribal women would help understand the pattern of changes in comparison to non-tribal women which may help in planning safe delivery. The result would also cater as a reference study for further large-scale study in the future.

Materials and Methods

Ethics
This study was approved by the Institutional Ethics Committee of Rajendra Institute of Medical Sciences, Ranchi, Jharkhand, India. The internal reference number of the approval was 106/ LAEC/IEC of RIMS. All the participants in this study were adults and voluntarily participated in the study after providing a written informed consent form. The informed consent form was prepared in Hindi and the message was conveyed in the local language with the help of a resident of the area to overcome any language barrier. Utmost care was taken to explain the study procedure, their voluntary participation, the risk, the benefit, and the freedom to withdraw from the study at any stage without stating any reason.[13]

Type and settings
This was a cross-sectional observational study to assess the pulmonary functions in three trimesters of pregnancy in healthy primigravida women by non-invasive tests. Research participants were enrolled in this study from the antenatal clinic of the department of obstetrics of the tertiary care hospital. The study state and site are shown on the Indian map in Figure 1. The age-matched and trimester-matched controls were recruited from the same antenatal clinic who were not members of the tribe and did not have any tribal linkage. This study was conducted from January to June 2018.

Recruitment process
The sample was a convenience sample recruited from the outpatient department of the antenatal clinic of the Department of Obstetrics. The recruitment process for the study and control group was continued for 6 months. Healthy primigravida women in the age group of 18–30 years were recruited for the study after taking written consent for voluntary participation. The apparent health status of the subject was determined by obtaining the medical history and a thorough physical and systemic examination of the participant. Any willing participants with hypertension, diabetes, tuberculosis, history of the cardiovascular or pulmonary or musculoskeletal system, obesity, anemic, or any acute illness like cough, sneezing, breathlessness, history of smoking, or alcohol consumption were excluded from the study.

Research participants
A total of 58 tribal primigravidae in the age group of 18–30 years attending the antenatal clinic participated in the study group. The trimester-wise distribution of the research participants is shown in Figure 2. There were 27 (46.55%) women in the first trimester (gestational age ≤12 weeks) pregnancy, 18 (31.03%)...
women in the second trimester (gestational age 13–28 weeks), and 13 (22.41%) women in the third trimester (gestational age 29–40 weeks). The uneven distribution of the participants in the three trimesters and the overall lower number are due to the difficulty in the availability of the tribal women attending during the study period. The control group was composed of 116 primigravidas in the age group of 18–30 years. A total of 42 (36.21%) in the first trimester, 42 (36.21%) in the second trimester, and 32 (27.58%) in the third trimester participated in the control group.

**Variables and measurement**

One expert clinician with a previous experience in anthropometric measurement conducted all the measurements. Age was recorded in completed years. Weight was measured by a digital weighing scale with an accuracy of 100 gm. Height was measured by a portable stadiometer to the nearest 1 mm while the subject was without shoes or socks and stood in Frankfurt's position with light clothing. The measurement was taken after a normal expiration.

The pulmonary function tests were measured by turbine flow sensor-based spirometer – Spiro Excel (Medicaid, Punjab, India). The tests were conducted by a single physiologist with expertise in measuring pulmonary function tests. There was the same-sex instructor from the tribal community for overcoming any language barrier. The participants did not have a meal within 2 h, performed any exercise in the preceding 30 min, and were on light clothing that did not restrict the chest or abdominal wall movement. The study participants were asked to rest for 15 min before measurement during which they explained the procedure. The subjects were in a sitting posture during the measurement. Each participant performed the test three times in each session.

**Statistical analysis**

Data were first tested for normal distribution to decide the presentation and statistical test. As the data were not normally distributed, they were expressed in median (first quartile [Q1] – third quartile [Q3]) format. The median of the

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**Table 1: Anthropometric parameters in non-tribal and tribal pregnant women**

| Category       | Trimester | Age (completed years) | Height (cm) | Weight (kg) | BMI (kg/m²) | Gestational age (weeks) | Respiratory rate (number) |
|----------------|-----------|-----------------------|-------------|-------------|-------------|-------------------------|---------------------------|
| Non-tribal     | 1st       | 21 (19-23.25)         | 153 (147.5-16) | 45 (43.51-25) | 19.77 (18.05-22.38) | 12 (11-12) | 16 (14.75-16) |
|                | 2nd       | 21.5 (19.75-24.75)    | 154 (151.5-156) | 52.5 (48.55-25) | 21.98 (19.93-23.94) | 24 (20-26.5) | 16 (15-18)  |
|                | 3rd       | 22.5 (21-26)          | 154 (150-155) | 56 (51-61) | 24.26 (21.71-25.76) | 32 (32-35) | 18 (16-18)  |
|                | Overall   | 22 (20-25)            | 154 (150-156) | 52 (45-56) | 21.74 (19.49-24.27) | 23.5 (12-30.25) | 16 (15-18) |
| Tribal         | 1st       | 22 (21-25)            | 156 (150-161) | 50 (45-55) | 21.08 (17.8-22.66) | 11 (10-12) | 18 (17-19) |
|                | 2nd       | 22 (20-25.4)          | 153.5 (149.5-157.75) | 55 (51.5-60) | 21.49 (19.52-22.72) | 24 (23.5-27.75) | 22 (19-25.45) |
|                | 3rd       | 24 (21-25.5)          | 154 (150-161) | 55 (51.5-60) | 21.49 (19.52-22.72) | 24 (23.5-27.75) | 22 (19-25.45) |
|                | Overall   | 22 (21-25)            | 154.5 (150-160.25) | 52 (47.55) | 21.57 (19.53-22.6) | 20.5 (11-28) | 20 (18-24.5) |

K-W: Kruskal–Wallis test (post hoc test was conducted with Bonferroni correction of α) was conducted with first, second, and third trimester data across the column. Trimesters having a statistically significant difference in the post hoc tests are shown with the P values. Mann–Whitney U tests were conducted between the non-tribal and tribal populations in different trimesters of pregnancy and the overall sample.

*Statistically significant P values

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Figure 2: Recruited number of non-tribal and tribal women according to the trimesters
two groups (e.g., tribal vs. non-tribal) was tested by the Mann–Whitney U test, and the median of the three groups (e.g., first, second, and third trimester) was tested by the Kruskal–Wallis test with a post hoc test where there was a statistically significant difference among the medians. For the entire test, a \( P < 0.05 \) was considered statistically significant. We used GraphPad Prism 6.01 (GraphPad Software, CA, USA) and Statistics Kingdom (online statistical tests in the public domain https://www.statskingdom.com) for carrying out the statistical tests.

### Results

A total of 58 tribal women with a median age of 22 (Q1–Q3: 21–25) years and 116 non-tribal women with a median age of 22 (20–25) \( P = 0.33 \) participated in the study. Their age (completed years), height (cm), weight (kg), BMI (kg/m\(^2\)), gestational age (weeks), and respiratory rate are shown in Table 1. The respiratory rates in the tribal women were higher in the first trimester (18 [17–19] per min vs. 16 [14.75–16] per min, \( P < 0.0001 \), second trimester (22 [19.75–24.5] per min vs. 16 [15–18] per min, \( P < 0.0001 \)), and third trimester (30 [25–34.5] per min vs. 18 [16–18] per min, \( P < 0.0001 \)). The overall sample including all women also showed a higher respiratory rate in the tribal women (20 [18–24.5] per min vs. 16 [15–18] per min, \( P < 0.0001 \)).

Pulmonary functions in the first trimester are shown in Table 2. The tribal women showed higher MMEF in first-trimester pregnancy (1.46 [1.12–1.79] L/s vs. 1.24 [1.04–1.5] L/s, \( P = 0.047 \)). Table 3 shows the tests in the second trimester. There was a higher PEFR (4.02 [2.78–4.11] L/s vs. 3.15 [2.58–3.87] L/s, \( P = 0.047 \)) in the second trimester. Table 4 shows the test parameters in the third trimester and there was no difference among the non-tribal and tribal women in the pulmonary functions in the third trimester of pregnancy. The tests parameters in the overall sample shows that the tribal women had higher PEFR (3.82 [2.96–4.33] L/s vs. 3.3 [2.73–4.05] L/s, \( P = 0.02 \)) and MMEF (1.43 [0.99–1.7] L/s vs. 1.21 [1–1.47] L/s, \( P = 0.04 \)) when compared to non-tribal women.

### Discussion

Healthcare delivery and acceptance among the tribal population in India face several challenges.\(^{[14]}\) Among the Indian 8.6% tribal population, the disease burden is almost four times that of the non-tribal population. Several communicable and non-communicable diseases are taking a higher toll from the tribal population. Hence, the healthcare delivery system should be strengthened along with increasing awareness about health-seeking behavior.\(^{[15,16]}\) Malnutrition, one of the silent causes of overall mortality and morbidity, should be tackled with the promotion of healthy food habits. During pregnancy, the respiratory rate is increased with the increment of the gestational age. It is attributed to the pressure of the abdomen to the diaphragm, increased cardiac output, hemodilution, and increased fetal oxygen demand.\(^{[17]}\) In our study, we found a higher respiratory rate among the tribal population during pregnancy.

### Table 2: Pulmonary function test in the first trimester in non-tribal and tribal pregnant women

| Test | Category | Non-tribal (n=42) | Tribal (n=27) | \( P \) |
|------|----------|------------------|---------------|-------|
| FVC  | Predicted | 3.29 (3.08–3.49) | 3.47 (3.17–3.7) | 0.08  |
|      | Observed  | 2.23 (2.04–2.45) | 2.22 (2.09–2.53) | 0.40  |
|      | % of predicted | 68.5 (62.25–73.5) | 67 (60–80) | 0.52  |
| FEV1 | Predicted | 2.86 (2.69–3.05) | 3.03 (2.77–3.23) | 0.09  |
|      | Observed  | 1.86 (1.7–2) | 1.95 (1.78–2.05) | 0.19  |
|      | % of predicted | 65 (59.75–70.5) | 64 (58–72) | 0.95  |
| PEFR | Predicted | 6.62 (6.35–6.85) | 6.84 (6.46–7.13) | 0.06  |
|      | Observed  | 3.41 (2.78–4.1) | 3.85 (3.36–4.3) | 0.07  |
|      | % of predicted | 52.5 (45.75–59.25) | 56 (49–71) | 0.051 |
| MMEF | Predicted | 4.1 (4.01–4.19) | 4.13 (4.01–4.21) | 0.82  |
|      | Observed  | 1.24 (1.04–1.5) | 1.46 (1.12–1.79) | 0.047* |
|      | % of predicted | 30 (25.75–35.25) | 35 (26–40) | 0.03* |
| FEV1/ FVC | Predicted | 85.21 (84.92–85.49) | 84.73 (84.35–85.11) | 0.0004* |
|      | Observed  | 87.29 (91.75–91.44) | 87.20 (83.62–93.2) | 0.47  |
|      | % of predicted | 102 (96–107.25) | 104 (100–110) | 0.20  |

P: Forced vital capacity, FEV1: Forced Expiratory Volume in the first second, PEFR: Peak expiratory flow rate, MMEF: Maximal Mid Expiratory Flow. *Statistically significant P-value of Mann-Whitney U test (the non-parametric test was used to compare the median as the data were not following a normal distribution).

### Table 3: Pulmonary function test in the second trimester in non-tribal and tribal pregnant women

| Test | Category | Non-tribal (n=42) | Tribal (n=27) | \( P \) |
|------|----------|------------------|---------------|-------|
| FVC  | Predicted | 3.31 (3.08–3.4) | 3.33 (3.05–3.46) | 0.68  |
|      | Observed  | 2.21 (2.00–2.47) | 2.18 (1.85–2.35) | 0.42  |
|      | % of predicted | 69.5 (60–76) | 68 (56.5–71.25) | 0.16  |
| FEV1 | Predicted | 2.89 (2.69–2.97) | 2.97 (2.65–3.02) | 0.77  |
|      | Observed  | 1.9 (1.75–2.02) | 1.89 (1.69–1.93) | 0.33  |
|      | % of predicted | 67.5 (58.75–73) | 63.5 (56.25–67) | 0.19  |
| PEFR | Predicted | 6.64 (6.36–6.75) | 6.625 (6.35–6.78) | 0.97  |
|      | Observed  | 3.15 (2.58–3.87) | 4.02 (2.78–4.41) | 0.047* |
|      | % of predicted | 47.5 (38.55–55) | 59.5 (44.68–75) | 0.06  |
| MMEF | Predicted | 4.09 (3.59–4.15) | 4.07 (3.99–4.16) | 0.97  |
|      | Observed  | 1.15 (1.02–1.47) | 1.42 (0.98–1.7) | 0.18  |
|      | % of predicted | 29 (25.25–35.25) | 36 (23.75–41.5) | 0.12  |
| FEV1/ FVC | Predicted | 85.04 (84.35–85.3) | 85.02 (84.73–85.3) | 0.85  |
|      | Observed  | 84.83 (80.42–88.74) | 86.42 (82.74–92.84) | 0.11  |
|      | % of predicted | 98 (88–104.25) | 101 (94.75–107.25) | 0.19  |

P: Forced vital capacity, FEV1: Forced Expiratory Volume in the first second, PEFR: Peak expiratory flow rate, MMEF: Maximal Mid Expiratory Flow. *Statistically significant P-value of Mann-Whitney U test (the non-parametric test was used to compare the median as the data were not following a normal distribution).

This finding may be attributed to the underlying malnutrition.\(^{[18]}\) However, we did not explore the relationship between the higher respiratory rate and malnutrition in this study and future studies may be conducted to find the relationship.

The pulmonary function test parameters were decreased with the increment of gestational age and the cause is primarily
Table 4: Pulmonary function test in the third trimester in non-tribal and tribal pregnant women

| Test       | Category | Non-tribal (n=32) | Tribal (n=13) | P  |
|------------|----------|-------------------|---------------|----|
|            |          | Median (Quartile 1 – Quartile 3) |                |    |
| FVC (L)    | Predicted| 3.15 (3.01-3.4)   | 3.07 (3.01-3.5) | 0.99 |
|           | Observed | 2.075 (1.91-2.28) | 2.11 (1.95-2.34) | 0.63 |
| % of predicted |       | 64.5 (58.5-71.75) | 69 (61.5-70) | 0.28 |
| FEV1 (L)   | Predicted| 2.745 (2.62-2.97) | 2.67 (2.62-3.06) | 0.99 |
|           | Observed | 1.82 (1.56-1.94) | 1.83 (1.56-2.03) | 0.82 |
| % of predicted |       | 62 (58-69) | 70 (62.71-70) | 0.11 |
| PEFR (L/s) | Predicted| 6.48 (6.28-6.99) | 6.73 (6.26-7.06) | 0.76 |
|           | Observed | 3.035 (2.68-4.3) | 3.2 (2.32-4.62) | 0.81 |
| % of predicted |       | 51 (43.5-62.75) | 48 (35.5-50.7) | 0.59 |
| MMEF (L/s) | Predicted| 4.04 (3.92-4.3) | 4.06 (3.85-4.16) | 0.77 |
|           | Observed | 1.22 (0.98-1.42) | 1.03 (0.82-1.64) | 0.93 |
| % of predicted |       | 30.5 (24.5-36) | 26 (22.39-70) | 0.78 |
| FEV1/ FVC (%) | Predicted| 84.35 (84.16-84.92) | 84.73 (84.35-85.21) | 0.07 |
| FVC (L)    | Observed | 86.645 (80.61-94.59) | 83.69 (77.35-90.03) | 0.56 |
| % of predicted |       | 102.5 (98.109) | 99 (97-106) | 0.47 |

FVC: Forced vital capacity, FEV1: Forced Expiratory Volume in the first second, MMEF: Maximal Mid Expiratory Flow. *Statistically significant P values are of Mann–Whitney U test (this non-parametric test was used to compare the median as the data were not following a normal distribution).

Table 5: Pulmonary function test in the overall sample in non-tribal and tribal pregnant women

| Test       | Category | Non-tribal (n=32) | Tribal (n=13) | P  |
|------------|----------|-------------------|---------------|----|
|            |          | Median (Quartile 1 – Quartile 3) |                |    |
| FVC (L)    | Predicted| 3.26 (3.07-3.45) | 3.38 (3.06-3.61) | 0.15 |
|           | Observed | 2.19 (1.98-2.41) | 2.21 (2.2-2.4) | 0.56 |
| % of predicted |       | 68 (60-73) | 68 (58-73) | 0.87 |
| FEV1 (L)   | Predicted| 2.83 (2.68-3.01) | 2.95 (2.67-3.16) | 0.18 |
|           | Observed | 1.86 (1.7-1.99) | 1.89 (1.75-1.99) | 0.52 |
| % of predicted |       | 65.5 (59-70) | 64.5 (58-71) | 0.91 |
| PEF (L/s)  | Predicted| 6.6 (6.35-6.83) | 6.73 (6.36-7.02) | 0.14 |
|           | Observed | 3.3 (2.73-4.05) | 3.82 (2.96-4.33) | 0.02* |
| % of predicted |       | 50 (43-59) | 55 (46-68.75) | 0.02* |
| MMEF (L/s) | Predicted| 4.09 (3.98-4.16) | 4.1 (3.95-4.17) | 0.59 |
|           | Observed | 1.21 (1.1-1.47) | 1.43 (0.99-1.7) | 0.04* |
| % of predicted |       | 30 (26-35.75) | 35 (24.75-40) | 0.03* |
| FEV1/ FVC (%) | Predicted| 84.92 (84.35-85.3) | 84.92 (84.35-85.12) | 0.43 |
| FVC (L)    | Observed | 85.91 (80.79-90.34) | 86.78 (81.31-91.44) | 0.26 |
| % of predicted |       | 100.5 (94.25-106.75) | 102 (95.75-107) | 0.19 |

FVC: Forced vital capacity, FEV1: Forced Expiratory Volume in the first second, MMEF: Maximal Mid Expiratory Flow. (L/s) (this non-parametric test was used to compare the median as the data were not following a normal distribution).

In our study, we found that in tribal women, the MMEF in the first trimester and FEV1 in the second trimester were higher than in non-tribal women. However, there was no difference in the third trimester. This indicates a higher capability of exhalation in tribal women. The underlying cause may be attributed to muscular strength, especially in internal intercostal and abdominal muscles. In age increases, the abdominal muscles are distended due to the pressure of the growing fetus. This may be the cause of no difference in pulmonary function tests parameters in the third trimester of pregnancy.

Primary care physicians working in peripheral health care settings in India cater to the majority of the tribal population with limited resources. The knowledge about the pulmonary function among them would facilitate decision-making about the treatment and referral.

Novelty and limitations

This is the first study to report the comparative pulmonary function tests in tribal and non-tribal women in this state of India. This would help the physiologist and pulmonologist to get the first insight into the pulmonary functions in tribal women during the three trimesters of pregnancy where there are changes in both hormonal and mechanical factors. However, this study has several limitations. As this was a non-probability sample, its generalization should be interpreted with caution. A future study with a larger number of participants would increase the power of the study. However, we were limited by time and resources to recruit more tribal women for the study.

Conclusion

This is the first study to report the pulmonary functions in three trimesters of pregnancy among tribal women in Ranchi, Jharkhand, India. The comparative pulmonary functions with the non-tribal women showed that the respiratory rate, MMEF, and PEF are higher in tribal women. The sample of this study was in a normal physiological state without any disease. Hence, a higher MMEF and PEF in tribal women suggest their higher capability of exhalation capacity. The result of this initial study may serve as the basis of a future study with a larger sample size for a more generalizable result.

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Conflicts of interest

There are no conflicts of interest.

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