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ORIGINAL RESEARCH ARTICLE

# A Longitudinal Analysis of Disease Activity and Lung Function in Patients with Chronic Joint Disorders: Correlation with Disease Duration

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## ABSTRACT

**Introduction**: Rheumatoid arthritis (RA) is a chronic autoimmune disease that primarily affects joints but can also cause significant pulmonary complications, such as interstitial lung disease and pulmonary hypertension, leading to impaired lung function. Early identification of pulmonary involvement through pulmonary function tests (PFTs) is crucial to improving patient outcomes. This study assesses the correlation between the duration of RA and pulmonary function.

**Material and Methods**: A prospective cohort study was conducted at Shri Ram Murti Smarak Institute of Medical Sciences from August 2022 to January 2024, including 98 RA patients. Participants underwent clinical evaluation, laboratory tests, and PFTs (FEV1, FVC, and FEV1/FVC ratio) at baseline, one month, and three months. Disease activity was assessed using the DAS28 score. Data were analyzed using SPSS Version 25, with a *p-value* < 0.05 considered significant.

**Results**: Participants (mean age 40.98 ± 11.7 years) were predominantly female (80.6%). Disease activity improved over three months, with low activity increasing from 0% at admission to 38.8%. Significant improvements were observed in FEV1 (1.5 ± 0.3 to 1.7 ± 0.3 L, $p < 0.001$) and FEV1/FVC ratio (61.8–68.4%, $p < 0.001$).

**Conclusion**: Pulmonary function showed significant improvement with RA management over time, highlighting the importance of regular PFT monitoring to prevent respiratory complications.


**Keywords**: Rheumatoid arthritis, Pulmonary function tests, Disease activity, Spirometry, Autoimmune disease.

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## INTRODUCTION

Rheumatoid arthritis (RA) is a chronic, systemic autoimmune disorder characterized by inflammation of the synovial joints, leading to pain, stiffness, and progressive joint damage. Although traditionally associated with joint symptoms, RA can also have significant extra-articular manifestations, including pulmonary involvement.[1] Pulmonary complications in RA are a major cause of morbidity and can include conditions such as interstitial lung disease, pleural effusion, and pulmonary hypertension. These complications often contribute to respiratory dysfunction, which can impact the overall quality of life and functional status of patients.[2]

The pathogenesis of pulmonary involvement in RA is multifactorial, with both the disease itself and the therapies used to manage it, such as disease-modifying antirheumatic drugs (DMARDs), contributing to pulmonary damage. Early detection of pulmonary dysfunction is essential to prevent irreversible lung damage and improve patient outcomes.[3] Pulmonary function tests (PFTs) are commonly used to evaluate the extent of pulmonary involvement in various diseases, including RA. PFTs can provide objective data on lung function, offering insights into restrictive or obstructive patterns of lung disease, which can guide clinical management and treatment decisions.[4]

Previous studies have indicated that pulmonary manifestations in RA can develop early in the course of the disease, often before the onset of noticeable respiratory symptoms. These manifestations are sometimes underdiagnosed due to their insidious nature and overlap with other comorbidities.[5,6]

This study aims to assess pulmonary function in patients with rheumatoid arthritis and correlate the results of pulmonary function tests with the duration of illness. Understanding how the duration of RA correlates with pulmonary function can help identify patients at higher risk of developing respiratory complications. Furthermore, by closely monitoring these patients, it will be possible to implement early and appropriate treatment measures, potentially improving patient outcomes and reducing the burden of pulmonary complications in RA.

## MATERIAL AND METHODS

The study was conducted after obtaining approval from the Institutional Ethical Committee at Shri Ram Murti Smarak Institute of Medical Sciences, with written informed consent obtained from all participants. The study was carried out at the same institution, involving both male and female patients diagnosed with RA who were treated in the inpatient and outpatient departments. A prospective cohort design was used to collect data at the time of admission, and follow-up assessments were done at one month and three months to track changes over time.

The study was conducted over a period of 1.5 years, from August 2022 to January 2024. A total of 98 patients were included in the study. The sample size was determined using a conventional sampling method based on the inclusion and exclusion criteria applied during the study period without a pre-decided sample size. Inclusion criteria comprised patients diagnosed with clinically confirmed RA, meeting the American College of Rheumatology (ACR) 2010 criteria for RA. Exclusion criteria included individuals with chronic obstructive pulmonary disease (COPD), known interstitial lung disease, asthma, scoliosis, kyphosis, pulmonary tuberculosis, pregnant women, skeletal deformities, associated pulmonary disorders, chest trauma, neoplasms, and patients unwilling to participate in the study.

Written informed consent was obtained from each participant, and they underwent detailed medical history recording and clinical examination. Laboratory investigations, including complete blood count (CBC), renal function test (RFT), liver function test (LFT), serum uric acid, rheumatoid factor (RF), and anti-cyclic citrullinated peptide (Anti-CCP) antibodies, were conducted. Following this, participants underwent pulmonary function testing (PFT) in the pulmonary department.

The diagnosis of RA was confirmed using the EULAR 2010 classification criteria, which involves assessing joint involvement, serology, acute-phase reactants, and the duration of symptoms. A total score of 6 or more points from these domains was considered diagnostic of RA. Disease activity was assessed using the Disease Activity Score 28 (DAS28), which incorporates the number of tender and swollen joints, the erythrocyte sedimentation rate (ESR), and the patient's global health assessment. The DAS28 score was calculated using a formula that included these parameters, with interpretation indicating remission, low, moderate, or high disease activity based on the score.

Formula to calculate DAS28 = 0.56*sqrt (tender joints) + 0.28*sqrt (swollen joints) + 0.70*Ln (ESR) + 0.014*VAS[7] The DAS28 provides a number on a scale from 0 to 10, indicating current RA disease activity.

The calculation was done using an online portal on https://www.mdcalc.com/calc/2176/disease-activity-score-28-rheumatoid-arthritis-esr-das28-esr[8]

Pulmonary function was assessed using spirometry to measure forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio, allowing for the identification of restrictive or obstructive patterns in lung function.

Data collected from participants were entered into MS Excel and then analyzed using IBM SPSS version 25.0. Descriptive statistics and Pearson correlation coefficient were calculated, and the significance of differences between groups was assessed using unpaired t-tests for quantitative data. A *p-value* of less than 0.05 was considered statistically significant for identifying associations between groups.

## RESULTS

The study participants were predominantly ≤40 years old (54.1%), followed by 24.5% in the 41 to 50 years age group and 21.4% ≥51 years old. Of the total 98 participants, 80.6% were female and 19.4% were male. The mean age was 40.98 ± 11.7 years, with average height, weight, and BMI of 153.63 ± 8.7 cm, 60.45 ± 8.6 kg, and 25.72 ± 3.9 kg/m², respectively. BMI classification showed 32.7% of participants were normal weight, 19.4% overweight, 35.7% pre-obese, and 12.2% obese. Disease duration was <5 years for 35.7% and ≥5 years for 64.3%, with a mean duration of 10.81 ± 7.1 years.

At admission, most participants (92.9%) had moderate disease activity, with 7.1% in the high activity category. By month 1, 19.4% had low disease activity, which increased to 38.8% by month 3. Swollen and tender joints were recorded, with 26.5% showing one swollen joint at admission, which decreased over time. Tender joints increased from 12.2% at admission to 24.5% by month 3. Both erythrocyte sedimentation rate (ESR) and patients' global health scores improved significantly, with ESR decreasing from 23.38 ± 5.1 mm/hr at admission to 16.9 ± 1.7 mm/hr at three months and global health scores improving from 47.36 ± 17.4 to 26.05 ± 8.9. Table 1 shows that admission, month 1 and 3. Upon admission, 92.9% of participants had moderate disease activity, with 7.1% in the high range. By month 1, 19.4% had low disease activity, rising to 38.8% by month 3. The proportion with moderate activity decreased to 61.2%, and no participants were in the high activity category by month 1 or month 3, indicating improvement. Lung function, measured by FEV1, FVC, FEV1/FVC ratio, and PEF, showed significant improvement (Figure 1). FEV1 increased from 1.5 ± 0.3

**Table 1:** Joint involvement and lung function parameters at different follow-ups (n = 98)

| *Category* | *On admission* | *At month 1* | *At month 3* |
|---|---|---|---|
| *Disease activity* | | | |
| Low disease activity (2.6–3.2) | 0 | 19 (19.4%) | 38 (38.8%) |
| Moderate disease activity(≥3.2–5.1) | 91 (92.9%) | 79 (80.6%) | 60 (61.2%) |
| High disease activity (>5.1) | 7 (7.1%) | - | - |
| Swollen joints | | | |
| 1 swollen joint | 26 (26.5%) | 18 (18.4%) | 25 (25.5%) |
| 2 swollen joints | 17 (17.3%) | 17 (17.3%) | 21 (21.4%) |
| 3 swollen joints | 8 (8.2%) | 14 (14.3%) | 30 (30.6%) |
| 4 swollen joints | 10 (10.2%) | 18 (18.4%) | 22 (22.4%) |
| 5 swollen joints | 19 (19.4%) | 31 (31.6%) | - |
| 6 swollen joints | 18 (18.4%) | - | - |
| Tender Joints | | | |
| 1 tender joint | 12 (12.2%) | 18 (18.4%) | 24 (24.5%) |
| 2 tender joints | 17 (17.3%) | 9 (9.2%) | 21 (21.4%) |
| 3 tender joints | 12 (12.2%) | 15 (15.3%) | 27 (27.6%) |
| 4 tender joints | 10 (10.2%) | 14 (14.3%) | 26 (26.5%) |
| 5 tender joints | 5 (5.1%) | 21 (21.4%) | - |
| 6 tender joints | 12 (12.2%) | 21 (21.4%) | - |
| 7 tender joints | 14 (14.3%) | - | - |
| 8 tender joints | 16 (16.3%) | - | - |
| *Lung parameters* | *On admission* | *At month 3* | *p-value* |
| FEV1 (liters) | 1.5 ± 0.3 | 1.7 ± 0.3 | <0.001* |
| FVC (liters) | 2.56 ± 0.3 | 2.61 ± 0.4 | 0.54 |
| FEV1/FVC (%) | 61.8 ± 14.1% | 68.4 ± 13.1% | <0.001* |
| PEF (liters/min) | 4.5 ± 1.2 | 6.6 ± 0.8 | <0.001* |

**Table 2:** Respiratory defect among study participants (n = 98).

| *Respiratory defect* | *Frequency* | *Percent* |
|---|---|---|
| Normal | 65 | 66.3 |
| Restrictive | 28 | 28.6 |
| Obstructive | 5 | 5.1 |
| Total | 98 | 100 |

liters at admission to 1.7 ± 0.3 liters at three months, FVC from 2.56 ± 0.3 to 2.61 ± 0.4 liters, and the FEV1/FVC ratio from 61.8 to 68.4%. PEF improved from 4.5 ± 1.2 liters/min to 6.6 ± 0.8 liters/min ($p < 0.001$ for all parameters).

Table 2 shows that based on spirometry into three categories: Normal, restrictive, and obstructive. Among 98 participants, 65 (66.3%) had normal respiratory function. Restrictive defects were observed in 28 participants (28.6%), suggesting possible issues with lung expansion or compliance. Only 5 participants (5.1%) showed obstructive defects, indicating airflow limitation typically seen in conditions like asthma or COPD.

Table 3 shows that Among 98 participants, 65 (66.3%) had normal respiratory function. Restrictive defects were observed in 28 participants (28.6%), suggesting possible issues with lung expansion or compliance. Only 5 participants (5.1%) showed obstructive defects, indicating airflow limitation typically seen in conditions like asthma or COPD. The Pearson correlation coefficient also demonstrated significant negative correlations between lung function parameters and disease duration ($p < 0.001$ for all parameters) (Table 4).

**Table 3:** Correlation of lung parameters with disease duration (n = 98)

| *Lung parameter* | *<5 years (n = 35)* | *≥5 years (n = 63)* | *Total (n = 98)* | *p-value* |
|---|---|---|---|---|
| FEV1 (liters) | 2.1 ± 0.1 | 1.6 ± 0.2 | 1.7 ± 0.3 | <0.001* |
| FVC (liters) | 3.1 ± 0.1 | 2.3 ± 0.3 | 2.6 ± 0.4 | <0.001* |
| FEV1/FVC (%) | 68.1 ± 1% | 66.4 ± 2.2% | 66.1 ± 2% | <0.001* |
| PEF (liters/min) | 7.3 ± 0.3 | 6.1 ± 0.5 | 5.5 ± 0.7 | <0.001* |

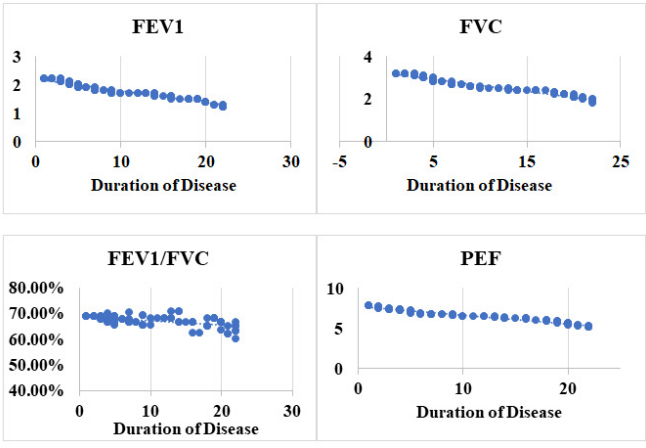


**Figure 1:** Correlation of lung function parameter with duration of diseases

**Table 4:** Correlation of lung parameters with disease duration (n = 98)

| *Correlation of lung parameters with disease duration* | *Pearson correlation* | *p-value* |
|---|---|---|
| FEV1 (liters) | -0.99 | <0.001* |
| FVC (liters) | -0.98 | <0.001* |
| FEV1/FVC (%) | -0.83 | <0.001* |
| PEF (liters/min) | -0.97 | <0.001* |

## DISCUSSION

The present study explored the demographic distribution of participants across different age groups and genders, revealing no significant association between age group and gender ($\chi^2$ = 0.043, $p$ = 0.97). The distribution demonstrated a predominance of females, with 80.6% being women and 19.4% being men, suggesting that the sample aligns with the known higher prevalence of conditions like rheumatoid arthritis (RA) among women.

In comparison, Assadi *et al*. also reported a higher female-to-male ratio, reflecting the gender bias commonly observed in RA patients.[9] However, despite the skewed gender distribution, they found no significant correlation between age groups and gender, similar to our study's findings. Notably, Assadi *et al*.'s study imposed an upper age limit of 58 years due to potential limitations with lung function tests, emphasizing the impact of pulmonary function in RA management.[9] In contrast to our broader age range, their study focused on younger patients with active disease, which may have influenced their observations on gender-related differences. Malode *et al*. categorized participants into the same three age groups (≤40, 41–50, ≥51 years) as our study, also finding no significant gender variation across these groups.[10] Their study, however, went a step further to examine the relationship between disease severity and pulmonary function parameters, particularly the FEV1/FVC ratio. The statistically significant differences observed in the disease activity score 28 (DAS28) among cases with varying levels of pulmonary impairment highlight a potential link between respiratory function and RA severity—a focus absent in our demographic analysis.

Our study the anthropometric characteristics, showing a mean age of 40.9 ± 11.7 years, average height of 153.63 ± 8.7 cm, weight of 60.45 ± 8.6 kg, and a mean BMI of 25.72 ± 3.9. This profile indicates a sample skewed towards the overweight category. Comparatively, the study by Iqbal *et al*. demonstrated a significant relationship between increased BMI and disease activity in RA patients, highlighting that a higher BMI correlates with elevated RAPID3 scores and CRP levels, suggesting that obesity exacerbates systemic inflammation in RA.[11] In contrast, while documenting the distribution of BMI categories, we did not find a statistically significant association between BMI and disease activity.

Further supporting the link between obesity and RA, Roubenoff *et al*. found that patients with long-standing RA (mean duration >10 years) and higher BMI levels exhibited greater disease activity but no corresponding increase in joint damage or surgeries.[12] This finding underscores the complex relationship between obesity and RA, suggesting that while obesity may heighten disease activity, it does not necessarily accelerate structural joint damage.

In examining the disease dng participants in our study, we found that 64.3% of participants had been living with their condition for over five years, with a mean disease duration of 10.81 ± 7.1 years. The study by Avnon *et al*. similarly focused on disease progression over time, particularly in terms of respiratory outcomes.[13] They observed dynamic changes in pulmonary function among RA patients over a five-year period, indicating that the disease can cause evolving respiratory impairment.

Additionally, our demographic data a*Chang *et al*.'s findings, which reported a predominance of female participants with a mean age significantly higher than our cohort (66.5 years).[14] Their study also explored smoking as a risk factor, which may have contributed to the higher rates of disease-related complications observed in their older population. This demographic distinction emphasizes the impact of age and lifestyle factors on RA progression and comorbidities.

Swollen joint counts showed steady improvement over time. Initially, one swollen joint was most common (26.5%), followed by five joints (19.4%). By month 1, 1-joint cases decreased (18.4%) and 5-joint cases rose (31.6%), indicating a temporary inflammation increase. By month 3, 3-joint cases were most frequent (30.6%), with no cases of 5 or 6 swollen joints showing reduced severe inflammation.

Comparing these findings to the study by Schiff *et al*., which focused on treatment efficacy between abatacept and adalimumab, both groups demonstrated comparable reductions in swollen joint counts, with improvements of approximately 69% in both cohorts.[15] The study also showed similar gains in parameters like the physician's global assessment and pain relief, highlighting the therapeutic parity between the two biologics.

Fleischmann *et al*.'s research on etanercept showed a dose-dependent improvement in joint symptoms, although specific swollen joint counts were not detailed.[16] This study supports the efficacy of TNF-$\alpha$ inhibitors in reducing joint inflammation, aligning with the overall trend of improvement seen in the present study.

The research by Felson *et al*. emphasized the effectiveness of sulfasalazine in managing rheumatoid arthritis (RA), showing a 59% reduction in swollen joints, alongside significant improvements in pain and patient-reported outcomes.[17] This underscores sulfasalazine's potential for symptom control, comparable to the improvement patterns observed in our study over three months.

In contrast, Weinblatt *et al*. highlighted the superior efficacy of sulfasalazine over hydroxychloroquine in reducing swollen joints, with sulfasalazine achieving a 43% reduction in ESR and better pain relief.[18] The lower dropout rates due to efficacy in the sulfasalazine group (5 vs. 15% in the hydroxychloroquine group) further illustrate its effectiveness in disease management.

Regarding tender joint counts in our study, on admission, two tender joints were most common (17.3%), followed by one tender joint (12.2%). By the first-month follow-up, the prevalence of 1 tender joint increased to 18.4%, while two tender joints decreased to 9.2%, indicating symptomatic improvement. By Month 3, a majority of patients with >2 tender joints had shifted to ≤2 tender joints, reflecting significant symptom reduction.

The study by Zhuo *et al*. provides context on RA severity in patients with and without interstitial lung disease (ILD), showing that those with ILD had worse joint counts and higher medication needs.[19] The missing severity data in their analysis suggests a potential underestimation of RA symptoms in patients with lower disease activity.

In our study, disease activity scores also demonstrated a significant downward trend over time. Initially, 92.9% of patients had moderate disease activity, with 7.1% in the high-activity group. By month 1, no patients remained in the high activity category, with a shift towards moderate (80.6%) and low activity (19.6%). By month 3, the low activity group expanded to 38.8%, while moderate activity decreased to 61.2%, suggesting sustained symptom control.

Comparatively, the study by Magalhaes *et al*. explored joint symptoms and laboratory markers in a cohort, revealing prevalent joint and respiratory symptoms alongside abnormal inflammatory markers.[20] Despite varied remission rates based on different assessment tools, their findings align with the improvements in disease activity observed in our study.

Gantait *et al*. found a near-significant correlation between DAS28 scores and spirometry abnormalities, suggesting that patients with higher disease activity are at increased risk of lung dysfunction.[21] Though their study did not reach statistical significance due to a small sample size, it indicates a trend similar to our findings of decreasing inflammatory markers.

Our study also tracked ESR levels, which showed consistent improvement: 23.38 ± 5.1 mm/h at baseline, reducing to 19.19 ± 5.1 mm/h after one month, and further to 16.9 ± 1.7 mm/h by month 3. This downward trend suggests a favorable response to treatment. Comparatively, Lee *et al*. also monitored ESR and other inflammatory markers, finding correlations with lung function and disease activity, emphasizing the utility of ESR as a disease progression marker.[22]

Lastly, Gochuico *et al*. linked elevated CRP and ESR levels with declining lung function (DLCO), suggesting a potential link between systemic inflammation and pulmonary complications in RA patients.[23]

## CONCLUSION

This study revealed that participants predominantly were younger than 40 years, with a higher proportion of females. Disease activity decreased significantly over the three-month follow-up, with a shift from moderate to low disease activity. Joint swelling and tenderness showed mixed trends, with overall improvements observed. Notably, lung function parameters such as FEV1, FVC, and PEF improved significantly over time, especially in participants with shorter disease durations. The study underscores the link between prolonged disease duration and deteriorating lung function.

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