LUPUS SCIENCE & MEDICINE™

Pulmonary function, functional capacity and physical activity in patients with SLE: a cross-sectional study

Tugba Civi Karaaslan [1], Zelal Apaydın [2,3], Melis Usul [2,4], Serdal Ugurlu [5], Ela Tarakcı [1]

To cite: Civi Karaaslan T, Apaydın Z, Usul M, *et al*. Pulmonary function, functional capacity and physical activity in patients with SLE: a cross-sectional study. *Lupus Science & Medicine* 2026;**13**:e002284. doi:10.1136/lupus-2026-002284

Received 31 July 2026
Accepted 16 October 2026

Check for updates

© Author(s) (or their employer(s)) 2026. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ Group.

[1]Department of Physiotherapy and Rehabilitation, Istanbul University-Cerrahpasa, Istanbul, Turkey
[2]Physiotherapy and Rehabilitation, Istanbul University-Cerrahpasa Institute of Graduate Studies, Istanbul, Turkey
[3]Department of Physiotherapy and Rehabilitation, Istanbul Yeni Yuzyil University, Istanbul, Turkey
[4]Department of Physiotherapy and Rehabilitation, Istanbul Kent University, Istanbul, Turkey
[5]Internal Medicine, Istanbul University-Cerrahpasa, Cerrahpasa Faculty of Medicine, Fatih, Istanbul, Turkey

Correspondence to
Dr Tugba Civi Karaaslan; tugba.civi@iuc.edu.tr

ABSTRACT

Objective SLE is a chronic autoimmune disease. This study aimed to compare pulmonary function, maximal ventilatory capacity assessed by maximal voluntary ventilation (MVV), functional capacity, physical activity level, sleep quality and fatigue between patients with SLE and healthy controls.

Methods Respiratory function was assessed using spirometer. Functional capacity was evaluated with the 6-min walk test (6MWT), physical activity with the Global Physical Activity Questionnaire (GPAQ), sleep quality with the Pittsburgh Sleep Quality Index (PSQI) and fatigue with the Fatigue Severity Scale (FSS).

Results The cross-sectional study included 25 patients with SLE (21 women, 4 men; mean age 37.00±11.44 years) and 25 healthy controls (20 women, 5 men; mean age 32.24±5.86 years). Groups were similar in age and sex. Compared with healthy controls, patients with SLE had significantly lower forced vital capacity (FVC) (p=0.03), forced expiratory volume in 1 s (FEV_1) (p=0.01) and MVV (p<0.001). The 6MWT distance and GPAQ total score were also reduced (p<0.01). No differences were observed for FEV_1/FVC ratio (p=0.75), peak expiratory flow (p=0.32), PSQI (p=0.27) or FSS (p=0.26). In patients with SLE, MVV showed a moderate negative correlation with disease duration (r=−0.585) and a moderate positive correlation with exercise capacity (r=0.618). FEV_1 showed a borderline positive association with exercise capacity (r=0.384).

Conclusions Pulmonary function, exercise capacity and physical activity levels were reduced in patients with SLE compared with healthy controls. In addition, pulmonary function parameters were associated with disease duration and exercise capacity, highlighting the importance of early evaluation of respiratory function in patients with SLE.

Trial registration number NCT07193745.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Pulmonary involvement is a recognised manifestation of SLE that can lead to reduced functional capacity and physical activity levels.
⇒ Respiratory muscle dysfunction and fatigue are known to contribute to impaired overall functional performance and lower quality of life in chronic autoimmune conditions.

WHAT THIS STUDY ADDS

⇒ This study demonstrates that patients with SLE exhibit significantly reduced pulmonary function, maximal voluntary ventilation (MVV) and exercise capacity compared with healthy controls.
⇒ MVV negatively correlates with disease duration and positively correlates with exercise capacity, highlighting that respiratory muscle endurance declines as the disease progresses and directly impacts functional tolerance.
⇒ While respiratory function parameters are closely associated with exercise capacity, they show no significant association with fatigue or sleep quality in patients with SLE, indicating independent underlying clinical pathways.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ In clinical practice: early assessment of respiratory function in patients with SLE can enable prompt identification of impairments in functional capacity, facilitating timely therapeutic interventions.
⇒ In future research: future studies should incorporate evaluations of respiratory muscle strength and investigate long-term outcomes to better elucidate disease progression and functional trajectories over time.

INTRODUCTION

SLE is a chronic, inflammatory, autoimmune disease predominantly affecting women and characterised by multisystem involvement. With a highly heterogeneous clinical course, SLE can affect multiple organs and tissues, including the skin, joints, kidneys, central and peripheral nervous systems, lungs and heart.[1] SLE is an extremely heterogeneous disease, and its underlying pathophysiology remains incompletely understood.[2]

Pulmonary involvement is common in SLE and may affect a substantial proportion of patients at any stage of the disease course. Reported prevalence rates of SLE-related pulmonary involvement vary widely in the literature, ranging from 20% to 90%.[3] Approximately 12% of patients develop permanent

Lupus Science & Medicine: first published as 10.1136/lupus-2026-002284 on 2 November 2026. Downloaded from https://lupus.bmj.com on 8 November 2026 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

lung damage within 10 years following SLE diagnosis, and increasing age has been associated with earlier onset of pulmonary injury.[4] Pulmonary involvement in SLE often follows a subclinical course, with overt respiratory symptoms reported in only 4%–5% of patients. Pleuritis, diffuse alveolar haemorrhage, shrinking lung syndrome, interstitial lung disease and pulmonary arterial hypertension represent the major forms of pulmonary involvement associated with SLE.[5] These manifestations constitute a heterogeneous clinical spectrum involving the lung parenchyma, pleura and pulmonary vasculature. However, due to the limited number of clinical trials specifically targeting pulmonary manifestations of SLE, therapeutic decision-making is largely based on evidence derived from case reports and small case series.[3]

The presence of pulmonary involvement in SLE is not limited to respiratory symptoms and may also adversely affect functional capacity. Previous studies have demonstrated a significant association between dyspnoea and pulmonary disease, with patients exhibiting lung involvement showing significantly reduced performance on walking tests compared with those without pulmonary involvement.[6] Moreover, even in the absence of overt pulmonary dysfunction, patients with SLE have been shown to exhibit abnormal breathing patterns, respiratory muscle weakness and increased levels of fatigue.[7] These findings suggest that pulmonary involvement in SLE may lead to functional impairments beyond structural abnormalities. Nevertheless, existing evidence remains limited and heterogeneous, resulting in a lack of robust data to guide the evaluation and management of pulmonary complications in this population.[4] Therefore, careful and systematic assessment of respiratory involvement is recommended in the clinical evaluation of patients with SLE.[3]

Although previous studies have examined pulmonary function or exercise capacity separately in SLE, few studies have simultaneously investigated spirometric parameters, maximum voluntary ventilation (MVV), functional capacity, physical activity, fatigue and sleep quality in a clinically stable SLE population without diagnosed restrictive or interstitial lung disease.

Therefore, the primary aim of this study was to compare pulmonary function, maximal ventilatory capacity assessed by MVV, functional capacity, physical activity level, sleep quality and fatigue between patients with SLE and healthy controls. Additionally, we aimed to investigate the associations of pulmonary function parameters and MVV with functional capacity, physical activity level, sleep quality, fatigue and disease duration in patients with SLE.

METHODS

This cross-sectional study included 25 patients diagnosed with SLE according to the 2019 European League Against Rheumatism/American College of Rheumatology[8] classification criteria and 25 age-matched healthy controls. Individuals aged 18–65 years who had been diagnosed with SLE for at least 1 year, were able to ambulate independently, had no cognitive or mental impairments and provided written informed consent were eligible for inclusion. Exclusion criteria included the presence of major musculoskeletal disorders affecting the lower extremities, severe cardiovascular disease, pregnancy or a diagnosis of restrictive or interstitial lung disease. The control group consisted of healthy volunteers recruited from university staff using convenience sampling. Potential participants were screened according to the predefined eligibility criteria, and individuals with known medical conditions—including neurological, genetic or psychiatric disorders—that could potentially interfere with the study assessments were excluded. Healthy controls were selected to achieve a similar age and sex distribution to the SLE group.

The study was registered at ClinicalTrials.gov. Patients with SLE who were being followed at the Rheumatology Division of the Department of Internal Medicine, Istanbul University-Cerrahpasa were recruited for the study. Assessments were conducted between June 2025 and September 2025 at the Department of Physiotherapy and Rehabilitation, Istanbul University-Cerrahpasa, in accordance with the principles of the Declaration of Helsinki.

All participants received detailed information about the study protocol, and written informed consent was obtained prior to participation. Demographic and clinical data including age, sex, height, weight, body mass index (BMI), educational and occupational status, smoking history, disease duration and comorbidities were recorded by the investigators. Primary outcome measures were respiratory function, respiratory muscle endurance and functional capacity. Respiratory function was assessed using a digital spirometer (Pony FX, COSMED, Rome, Italy). Functional capacity was evaluated with the 6-min walk test (6MWT). Secondary outcome measures included physical activity level, sleep quality and fatigue severity. Physical activity level was assessed using the Global Physical Activity Questionnaire (GPAQ), sleep quality using the Pittsburgh Sleep Quality Index (PSQI) and fatigue severity using the Fatigue Severity Scale (FSS).

Pulmonary Function Test

Pulmonary function tests (PFTs) were performed using a digital spirometer in accordance with the American Thoracic Society (ATS) and European Respiratory Society (ERS) guidelines. Forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), the FEV_1/FVC ratio and peak expiratory flow (PEF) were measured. Three acceptable manoeuvres were obtained for each parameter, and the highest value was recorded. Predicted values (%) were calculated using reference equations adjusted for age, sex and height. Maximal ventilatory capacity was assessed using the MVV test. Participants were instructed to breathe as rapidly and deeply as possible for 12 s. MVV values and corresponding predicted percentages were recorded in accordance with ATS/ERS recommendations.[9]

Lupus Science & Medicine: first published as 10.1136/lupus-2026-002284 on 2 November 2026. Downloaded from https://lupus.bmj.com on 8 November 2026 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

6-Minute Walk Test

Functional capacity was evaluated using the 6MWT, a widely used and validated measure of exercise capacity in patients with SLE.[10] The test was conducted in accordance with ATS guidelines.[11] The 6MWT has also been used to assess functional capacity in chronic cardiac populations[12]; however, no cardiac-derived cut-off value was applied to the SLE population in the present study.

Global Physical Activity Questionnaire

Physical activity levels were assessed using the GPAQ developed by the WHO. The questionnaire comprises 16 items divided into four sections that assess work, transportation, leisure activities and sedentary behaviour over the past week. The total GPAQ score is calculated by summing the physical activity scores for work, transportation and leisure-time activities. GPAQ scoring is based on the number of days and minutes per week reported for each type of physical activity. The duration of each activity is multiplied by the corresponding metabolic equivalent (MET) value to calculate the total MET-minutes per week.[13] The value of 600 MET-minutes/week in the GPAQ is commonly used to define low physical activity or physical inactivity. The Turkish version of the questionnaire is validated.[14]

Pittsburgh Sleep Quality Index

Sleep quality was assessed using the PSQI, developed by Buysse *et al*. The PSQI consists of seven components—subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication and daytime dysfunction—each scored between 0 and 3. The global score ranges from 0 to 21, with scores >5 indicating poor sleep quality.[15] The Turkish version of the questionnaire is validated.[16]

Fatigue Severity Scale

Fatigue severity was evaluated using the FSS, developed by Krupp *et al*. The FSS consists of nine items scored on a 7-point Likert scale. The mean score is calculated, with values ≥4 indicating clinically significant fatigue.[17] The FSS is one of the most frequently recommended instruments for assessing fatigue in patients with SLE.[18] The Turkish version of the questionnaire is validated.[19]

Sample size

The sample size was calculated using G*Power software. The effect size (Cohen's d=1.04) was obtained from the 6MWT results of patients with SLE and healthy controls reported by Balsamo *et al*.[20] Using this effect size, a priori calculations indicated that at least 24 participants per group were required to achieve 95% power at an alpha level of 0.05, taking into account a potential 20% drop-out rate.

Statistical analysis

Data were analysed using SPSS V.25. Normality was assessed with the Shapiro-Wilk test. Quantitative variables were expressed as mean±SD, and qualitative variables as numbers and percentages. Between-group comparisons were performed using the independent samples t-test or Mann-Whitney U test according to distribution. Pearson or Spearman correlation analyses were conducted according to data distribution. A p value of <0.05 was considered statistically significant.

Patient and public involvement

Patients were first involved in the study during the data collection phase by participating in the study assessments. They were not involved in the development of the research question, the selection of outcome measures, the design of the study or the conduct of the research. On completion of the assessments, participants were informed of their individual test results and provided with an explanation of their clinical significance.

Use of artificial intelligence and assistive technologies

During the preparation of this manuscript, the authors used ChatGPT (GPT-4o mini, OpenAI, San Francisco, California, USA) for language translation and grammatical refinements. The authors explicitly state that generative Artificial intelligence tools were not employed to fabricate primary data, derive scientific findings or compose the core narrative of the manuscript. Following the application of these tools, all generated content was thoroughly reviewed, critically analysed and revised by the authors, who maintain full responsibility for the manuscript's final content and accuracy.

RESULTS

30 patients were examined and 5 were excluded from the study due to not meeting the inclusion criteria, leaving a total of 25 patients for evaluation. 30 healthy controls were examined in a similar manner. The final evaluation was conducted on 25 healthy controls because 5 did not agree to volunteer (figure 1).

25 patients with SLE and 25 healthy controls were included. There were no significant differences between the groups in terms of age (p=0.07), sex distribution (p=1.00), smoking status (p=0.46), alcohol use (p=1.00) and BMI (p=0.31). The mean disease duration in the SLE group was 3.46±3.13 years. The demographic and clinical characteristics of the groups are presented in table 1.

Compared with healthy controls, patients with SLE had significantly lower FVC (p=0.03), FEV_1 (p=0.01) and MVV values (p<0.001). 6MWT was also significantly reduced in the SLE group (p<0.001). GPAQ total score was significantly lower in patients with SLE (p=0.003). No significant differences were observed between the groups in terms of FEV_1/FVC ratio (p=0.75), PEF (p=0.32) and PSQI (p=0.27) and FSS (p=0.26). The respiratory functions, respiratory muscle endurance, exercise capacity, physical activity, sleep quality and fatigue levels of the groups are presented in table 2.

In patients with SLE, MVV showed a moderate negative correlation with disease duration (r=−0.585) and a moderate positive correlation with exercise capacity

Lupus Science & Medicine: first published as 10.1136/lupus-2026-002284 on 2 November 2026. Downloaded from https://lupus.bmj.com on 8 November 2026 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

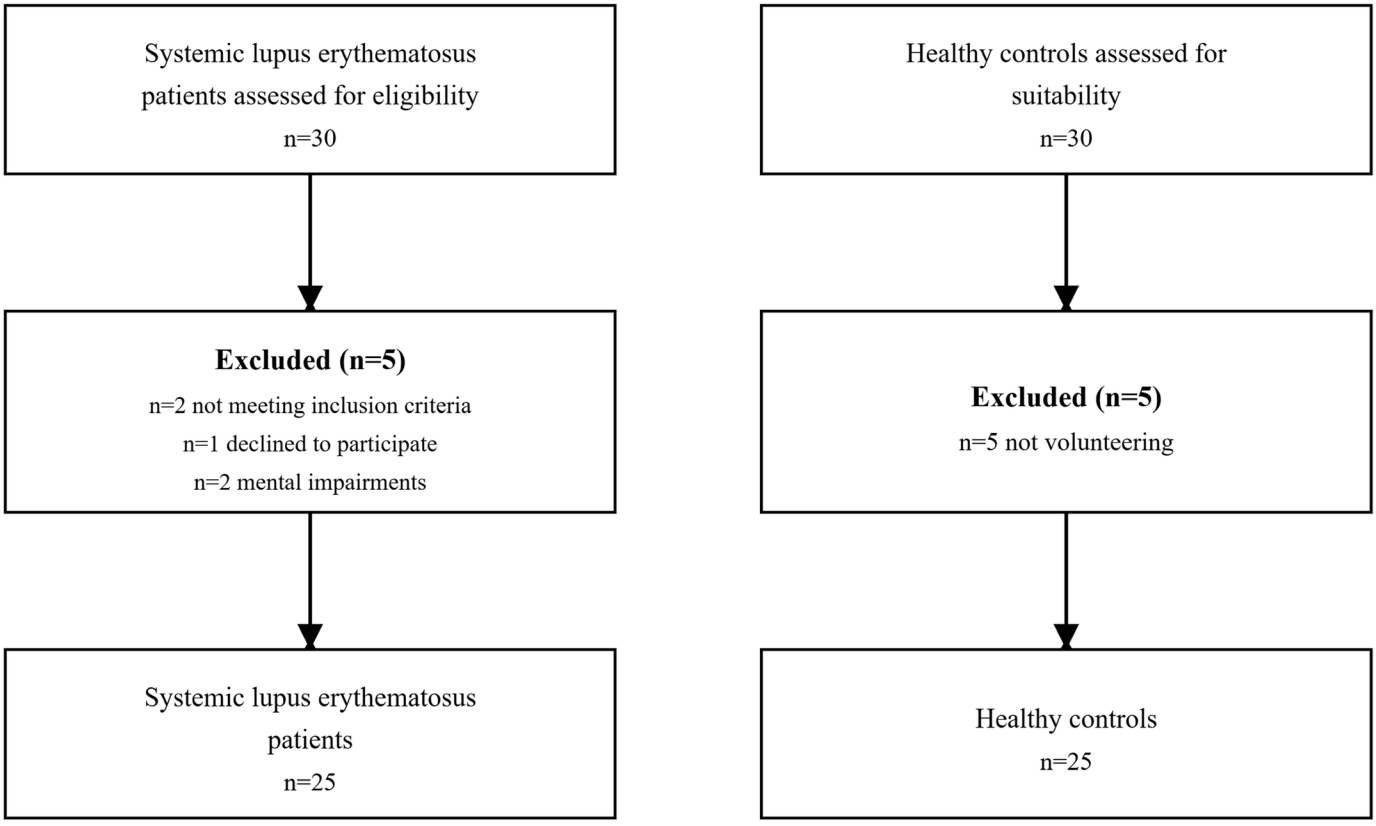


Figure 1 STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) flowchart.

(r=0.618). MVV was not significantly associated with sleep quality, fatigue or physical activity level (p>0.05). FEV_1 showed a borderline positive association with exercise capacity (r=0.384). There were no significant associations between FEV_1 and disease duration, sleep quality, fatigue or physical activity level (p>0.05). The correlations between respiratory function parameters and exercise capacity, sleep quality, physical activity and fatigue in patients with SLE are presented in table 3.

Table 1 Demographic and clinical characteristics of the groups

Variables	Patients with SLE (n=25), mean±SD or n (%)	Healthy controls (n=25), mean±SD or n (%)	P value
Age (years)	37.00±11.44	32.24±5.86	0.07*
Sex			
Female	21 (84)	20 (80)	1.00†
Male	4 (16)	5 (20)	
Smoking (yes/no)	6/19	3/22	0.46†
Alcohol use (yes/no)	0/25	1/24	1.00†
BMI (kg/m^2)	24.94±3.50	23.34±7.09	0.31*
Disease duration (years)	3.46±3.13		

*Independent sample t-test.
†χ^2 test.
BMI, body mass index.

DISCUSSION

In the present study, patients with SLE demonstrated impaired pulmonary function, reduced maximal ventilatory capacity and decreased exercise capacity compared with healthy controls. In addition, physical activity levels were significantly lower in the SLE group, while sleep quality and fatigue levels were comparable between groups. Respiratory muscle endurance and FEV_1 were moderately associated with exercise capacity while respiratory muscle endurance was also moderately associated with disease duration. However, respiratory muscle endurance and FEV_1 were not associated with sleep quality, fatigue or physical activity level. These findings suggest that respiratory involvement in SLE may primarily influence functional exercise performance rather than subjective symptoms such as sleep quality and fatigue.

PFT data frequently demonstrate abnormalities in patients with SLE. The prevalence of PFT abnormalities has been reported to reach up to 88%, with the most common findings being reduced diffusion capacity, decreased lung volumes and hypoxemia.[21 22] Restrictive ventilatory abnormalities are commonly reported in

Lupus Science & Medicine: first published as 10.1136/lupus-2026-002284 on 2 November 2026. Downloaded from https://lupus.bmj.com on 8 November 2026 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Table 2 Respiratory functions, respiratory muscle endurance, exercise capacity, physical activity, sleep quality and fatigue levels of the groups

Variables	Patients with SLE (n=25), mean±SD or n (%)	Healthy controls (n=25), mean±SD or n (%)	P value	Mean difference (95% CI)/effect Size
FVC (%)	86.76±14.38	94.44±10.30	**0.03***	−7.68 (−14.79 to −0.56)
FEV_1 (%)	75.80±12.36	85.24±13.95	**0.01***	−9.44 (−16.94 to −1.93)
FEV_1/FVC (%)	92.24±11.30	93.36±14.21	0.75*	−1.12 (−8.42 to 6.18)
PEF (%)	62.92±20.46	69.44±25.29	0.32*	−6.52 (−19.60 to 6.56)
MVV (%)	53.44±16.44	83.96±16.62	**<0.001***	−30.52 (−39.92 to −21.11)
6MWT	508.24±88.43	614.28±58.68	**<0.001***	−106.04 (−148.71 to −63.36)
GPAQ total score	666.40±501.94	1441.92±1058.71	**0.003†**	0.42
Physical activity classification (GPAQ)				
Active	13 (52.0%)	22 (88.0%)	**0.005‡**	
Inactive	12 (48.0%)	3 (12.0%)		
PSQI	6.72±3.57	5.76±2.50	0.27*	0.96 (−0.79 to 2.71)
FSS	4.19±1.91	3.47±1.29	0.26†	0.15

Mean difference is reported for the Independent Samples t-test, and effect size (r) for the Mann-Whitney U test.
Bold terms used as an indicator of statistical significance (p<0.05).
*Independent sample t-test.
†Mann-Whitney U test.
‡χ^2 test.
FEV_1, forced expiratory volume in 1 s; FSS, Fatigue Severity Scale; FVC, forced vital capacity; GPAQ, Global Physical Activity Questionnaire; MVV, maximum voluntary ventilation; 6MWT, 6 min walk test; PEF, peak expiratory flow; PSQI, Pittsburgh Sleep Quality Index.

patients with SLE. In patients with SLE, decreased FVC and FEV_1 values are observed, while the FEV_1/FVC ratio is generally within normal limits.[23–25] Hussain *et al* reported that in 120 patients with SLE, FEV_1 and FVC values were lower than predicted values, whereas the FEV_1/FVC ratio was preserved. In addition, the decline in pulmonary function increased with longer disease duration.[25] Similarly, Alam *et al* reported significant reductions in FVC values with preserved FEV_1/FVC ratios in patients with juvenile SLE.[26] In line with our findings, FEV_1 and FVC values were reduced in patients with SLE compared with healthy controls, whereas the FEV_1/FVC ratio was preserved. These results are consistent with the existing literature. However, because lung volume and diffusion capacity measurements were not performed, these findings should not be interpreted as definitive evidence of restrictive ventilatory impairment and may instead reflect reduced ventilatory performance or subclinical respiratory involvement. In the literature, the relationship between SLE and PEF has been less extensively studied compared with other PFT parameters. Reductions in PEF were reported particularly in patients with severe pulmonary parenchymal involvement or accompanying significant muscle involvement.[27 28] Our findings showed that no significant difference in PEF values was found between patients with SLE and the control group. In line with the literature, the absence of marked pulmonary involvement and concomitant pulmonary disease in the patients with SLE included in our study may explain why no significant reduction in PEF values was observed. The severity of SLE

Table 3 Correlations of FEV_1 and MVV with exercise capacity, sleep quality, physical activity and fatigue in patients with SLE

	Disease duration		6MWT		PSQI		FSS		GPAQ	
	r	P value	r	P value	r	P value	r	P value	r	P value
MVV%	**−0.585***	**0.002**	**0.618***	**0.001**	−0.224*	0.282	0.03†	0.855	0.04†	0.849
FEV_1%	−0.381*	0.06	**0.384***	**0.05**	0.07*	0.732	0.20†	0.332	0.17†	0.392

Bold terms used as an indicator of statistical significance (p<0.05).
*Pearson test. †Spearman test.
FEV_1, forced expiratory volume in 1 s; FSS, Fatigue Severity Scale; GPAQ, Global Physical Activity Questionnaire; MVV, maximum voluntary ventilation; 6MWT, 6 min walk test; PSQI, Pittsburgh Sleep Quality Index.

Lupus Science & Medicine: first published as 10.1136/lupus-2026-002284 on 2 November 2026. Downloaded from https://lupus.bmj.com on 8 November 2026 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

was associated with respiratory function, with increased disease activity correlating with decreased lung function parameters.[27] In addition, SLE severity showed a significant negative correlation with lung function and was positively correlated with pleural abnormalities, including pleural thickness, pleural effusion and pleural nodules detected on ultrasonography.[29] In the present study, longer disease duration was associated with lower MVV.

MVV value, which is used in the assessment of respiratory muscle endurance, provides important clinical information regarding respiratory function.[30] In a study evaluating respiratory muscle fatigue through MVV measurements in 49 patients with SLE (mean age 45 years), the patients achieved only 55% of their predicted MVV values.[31] Our findings align with these observations, with patients in our study reaching only 53% of their predicted MVV values. Studies directly comparing MVV values between patients with SLE and healthy control groups are limited. In addition, MVV is considered an indirect indicator of respiratory muscle strength and functional capacity.[32] Maximal inspiratory pressures (MIPs) and maximal expiratory pressures (MEPs) were also found to be significantly reduced in 76 female patients with SLE (mean age 31 years) compared with 78 healthy controls, indicating decreased respiratory muscle strength.[33] In another study, MIP and MEP values were significantly lower in 23 patients with SLE compared with 17 healthy controls.[34] MVV was significantly lower in patients with SLE than in healthy controls. Because MVV reflects an integrated response influenced by respiratory muscle function, ventilatory mechanics, airway characteristics, coordination and participant effort, this finding should not be interpreted as a direct measurement of respiratory muscle strength or endurance. Previous studies reporting reduced MIP and MEP in patients with SLE suggest that respiratory muscle dysfunction may contribute to impaired ventilatory performance; however, direct respiratory muscle strength measurements were not performed in the present study.

Previous studies have consistently demonstrated reduced functional capacity in patients with SLE compared with healthy controls.[20 35] Consistent with previously reported data, reduced 6MWT distances have been observed in patients with SLE compared with healthy controls in our study. These findings confirm that functional capacity is impaired in individuals with SLE. The reduction in functional capacity in SLE is a multifactorial condition arising from the interaction of biological and psychosocial factors. Lower levels of physical activity, pain, organ involvement and chronic inflammation are among the factors considered responsible for the decreased functional capacity.[36 37] The relationship between 6MWT distance and pulmonary function in SLE was not clearly established. Patients with SLE who had pulmonary involvement exhibited reduced 6MWT distances, and this reduction was associated with dyspnoea.[6] Similarly, in interstitial lung disease associated with connective tissue disorders, significant correlations were reported between 6MWT distance and PFTs such as FEV_1, FVC and diffusing capacity of the lung for carbon monoxide.[38] MVV was positively associated with 6MWT distance. FEV_1 also showed a positive, borderline association with 6MWT distance (r=0.384); therefore, this finding should be interpreted cautiously.

Total moderate to vigorous physical activity (MVPA) was reported to be significantly lower in patients with SLE compared with healthy controls. It was also reported that patients with more severe organ damage have lower levels of physical activity.[39] A study using wrist-worn activity trackers found that the daily physical activity levels of patients with SLE were significantly lower than those of healthy individuals of the same age.[40] Similarly, accelerometer-based measurements showed that MVPA was markedly lower in patients with SLE than in healthy controls.[41] Consistent with these findings, our study also demonstrated lower levels of physical activity in patients with SLE.

Fatigue is a significant factor affecting daily life in patients with SLE. The level of fatigue was higher in patients compared with controls.[42] Similarly, higher FSS scores have been reported in patients with SLE compared with healthy controls, and mean FSS scores above 4 indicate the presence of severe fatigue in these patients. Additionally, depression and sleep disorders were identified as determinants of fatigue.[43] Sleep disturbances and daytime dysfunction were more common in patients with SLE and were associated with increased fatigue.[44] The results of a meta-analysis showed that patients with SLE have poorer sleep quality compared with the general population.[45] Contrary to the studies mentioned, our study found no significant difference in patients' fatigue levels and sleep quality compared with healthy individuals. This finding may be explained by the relatively small sample size and the use of self-reported scales, which may limit the ability to obtain fully objective results.

Strengths and limitations

The present study had several strengths. First, it focuses on the early assessment of pulmonary function in patients with SLE, contributing to a relatively underexplored area of the literature. Second, the simultaneous evaluation of pulmonary function, respiratory muscle endurance, functional capacity, physical activity, sleep quality and fatigue provides a comprehensive assessment of the functional impairments associated with SLE.

The present study also has several limitations. First, disease activity and organ damage scores were not evaluated, and the potential effects of medication use and corticosteroid dosage were not analysed. Respiratory muscle strength and endurance were not directly assessed using measures such as MIP, MEP or sniff nasal inspiratory pressure. Therefore, the reduced MVV observed in the present study should be interpreted as reduced maximal ventilatory capacity rather than direct evidence of impaired respiratory muscle

Lupus Science & Medicine: first published as 10.1136/lupus-2026-002284 on 2 November 2026. Downloaded from https://lupus.bmj.com on 8 November 2026 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

strength or endurance. Finally, although the control group was generally comparable to the patient group in terms of age, the borderline difference in age between the groups may have influenced the results. Therefore, future studies should include samples that are more closely matched for age.

CONCLUSION

In our study, pulmonary function, exercise capacity and physical activity levels were reduced in patients with SLE compared with healthy controls. MVV was positively associated with exercise capacity, while FEV_1 showed a borderline positive association with exercise capacity.

MVV was also negatively associated with disease duration, indicating that longer disease duration was associated with lower maximal ventilatory capacity. However, no significant differences were observed between groups in terms of fatigue and sleep quality. Considering the potential impact of reduced pulmonary function on exercise capacity, respiratory function assessment and appropriate rehabilitation approaches may be beneficial for patients with SLE. Additionally, more detailed studies evaluating MIPs and MEPs, which provide clear information about respiratory muscle strength, are needed.

Acknowledgements This study was previously presented at the 2nd International Congress of Cardiopulmonary Rehabilitation in 2026.[46]

Contributors TCK contributed to the planning of the study, data collection, data analysis, interpretation of the results and preparation of the initial draft of the manuscript. TCK is the guarantor of the study and accepts responsibility for the overall content of the manuscript. ZA contributed to data collection, interpretation of the results, manuscript writing and critical revision of the manuscript. MU contributed to the study design, interpretation of the results, critical revision of the manuscript and supervision of the study conduct. ET and SU contributed to the study design, critical evaluation of the results and revision of the manuscript by reviewing its important scientific content. All authors reviewed and approved the final version of the manuscript. During the preparation of this manuscript, the authors used ChatGPT (GPT-4o mini, OpenAI, San Francisco, California, USA) for language translation and grammatical refinements. The authors explicitly state that generative AI tools were not employed to fabricate primary data, derive scientific findings or compose the core narrative of the manuscript. Following the application of these tools, all generated content was thoroughly reviewed, critically analysed and revised by the authors, who maintain full responsibility for the manuscript's final content and accuracy.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Non-Interventional Health Sciences Research Ethics Committee of Istanbul Yeni Yuzyil University (IRB: 2025/07-1614). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: https://creativecommons.org/licenses/by-nc/4.0/.

ORCID iDs
Tugba Civi Karaaslan https://orcid.org/0000-0002-8237-9290
Zelal Apaydın https://orcid.org/0000-0001-8640-8362
Melis Usul https://orcid.org/0000-0003-3991-278X
Serdal Ugurlu https://orcid.org/0000-0002-9561-2282
Ela Tarakcı https://orcid.org/0000-0003-1330-2051

REFERENCES

1 Parodis I, Girard-Guyonvarc'h C, Arnaud L, *et al*. EULAR recommendations for the non-pharmacological management of systemic lupus erythematosus and systemic sclerosis. *Ann Rheum Dis* 2024;83:720–9.
2 Moulton VR, Suarez-Fueyo A, Meidan E, *et al*. Pathogenesis of Human Systemic Lupus Erythematosus: A Cellular Perspective. *Trends Mol Med* 2017;23:615–35.
3 Amarnani R, Yeoh S-A, Denneny EK, *et al*. Lupus and the Lungs: The Assessment and Management of Pulmonary Manifestations of Systemic Lupus Erythematosus. *Front Med* 2021;7.
4 Hannah JR, D'Cruz DP. Pulmonary Complications of Systemic Lupus Erythematosus. *Semin Respir Crit Care Med* 2019;40:227–34.
5 Shin JI, Lee KH, Park S, *et al*. Systemic Lupus Erythematosus and Lung Involvement: A Comprehensive Review. *J Clin Med* 2022;11:6714.
6 Fidler L, Keen KJ, Touma Z, *et al*. Impact of pulmonary disease on patient-reported outcomes and patient-performed functional testing in systemic lupus erythematosus. *Lupus* 2016;25:1004–11.
7 Aldhahi MI, Wooten LC, Hasni S, *et al*. The association of breathing pattern with exercise tolerance and perceived fatigue in women with systemic lupus erythematosus: an exploratory case-control study. *Rheumatol Int* 2022;42:2003–11.
8 Aringer M, Costenbader K, Daikh D, *et al*. 2019 European League Against Rheumatism/American College of Rheumatology Classification Criteria for Systemic Lupus Erythematosus. *Arthritis & Rheumatology* 2019;71:1400–12.
9 Graham BL, Steenbruggen I, Miller MR, *et al*. Standardization of Spirometry 2019 Update. An Official American Thoracic Society and European Respiratory Society Technical Statement. *Am J Respir Crit Care Med* 2019;200:e70–88.
10 Leite MA, Pereira MC, Costallat LTL, *et al*. Evaluation of respiratory impairment in patients with systemic lupus erythematosus with the six-minute walk test. *Rev Bras Reumatol* 2014;54:192–9.
11 ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. *Am J Respir Crit Care Med* 2002;166:111–7.
12 Cavero-Redondo I, Saz-Lara A, Bizzozero-Peroni B, *et al*. Accuracy of the 6-Minute Walk Test for Assessing Functional Capacity in Patients With Heart Failure With Preserved Ejection Fraction and Other Chronic Cardiac Pathologies: Results of the ExIC-FEp Trial and a Meta-Analysis. *Sports Med Open* 2024;10:74.
13 Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health* 2009;6:790–804.
14 Adıgüzel İ, Raika Durusoy Onmuş İ, Mandıracıoğlu A, *et al*. Adaptation of the Global Physical Activity Questionnaire (GPAQ) into Turkish: A validation and reliability study. *Turk J Phys Med Rehabil* 2021;67:175–86.
15 Buysse DJ, Reynolds CF III, Monk TH, *et al*. The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Res* 1989;28:193–213.
16 Ağargün M. Pittsburgh uyku kalitesi indeksinin gecerligi ve guvenirligi. *Turk Psikiyatri Dergisi* 1996;7:107–15.
17 Krupp LB, LaRocca NG, Muir-Nash J, *et al*. The fatigue severity scale. Application to patients with multiple sclerosis and systemic lupus erythematosus. *Arch Neurol* 1989;46:1121–3.
18 Barbacki A, Petri M, Aviña-Zubieta A, *et al*. Fatigue Measurements in Systemic Lupus Erythematosus. *J Rheumatol* 2019;46:1470–7.
19 Armutlu K, Korkmaz NC, Keser I, *et al*. The validity and reliability of the Fatigue Severity Scale in Turkish multiple sclerosis patients. *Int J Rehabil Res* 2007;30:81–5.
20 Balsamo S, Nascimento D da C, Tibana RA, *et al*. The quality of life of patients with lupus erythematosus influences cardiovascular capacity in 6-minute walk test. *Rev Bras Reumatol* 2013;53:75–87.
21 Silberstein SL, Barland P, Grayzel AI. Pulmonary dysfunction in systemic lupus erythematosus:prevalence classification

Lupus Science & Medicine: first published as 10.1136/lupus-2026-002284 on 2 November 2026. Downloaded from https://lupus.bmj.com on 8 November 2026 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

and correlation with other organ involvement. *J Rheumatol* 1980;7:187–95.
22 Traynor AE, Corbridge TC, Eagan AE, *et al*. Prevalence and reversibility of pulmonary dysfunction in refractory systemic lupus: improvement correlates with disease remission following hematopoietic stem cell transplantation. *Chest* 2005;127:1680–9.
23 Eichacker PQ, Pinsker K, Epstein A, *et al*. Serial pulmonary function testing in patients with systemic lupus erythematosus. *Chest* 1988;94:129–32.
24 Veiga CS, Coutinho DS, Nakaie CMA, *et al*. Subclinical pulmonary abnormalities in childhood-onset systemic lupus erythematosus patients. *Lupus* 2016;25:645–51.
25 Hussain D, Begum S, Ali T, *et al*. Fvc, Fev1 and Fev1/Fvc % in Female SLE Patients and Their Relationship with Duration of the Disease. *Med Today* 2014;26:22–7.
26 Alam MM, Sarkar S, Ghosh P, *et al*. Spirometric evaluation in juvenile systemic lupus erythematosus. *Indian Pediatr* 2014;51:909–11.
27 Rolla G, Brussino L, Bertero MT, *et al*. Respiratory function in systemic lupus erythematosus: relation with activity and severity. *Lupus* 1996;5:38–43.
28 Paran D, Fireman E, Levartovsky D, *et al*. Pulmonary dysfunction in systemic lupus erythematosus and anti-phospholipid syndrome patients. *Scand J Rheumatol* 2007;36:285–90.
29 Hamed HS, Abozaid MMN, Mekawy E. Subclinical pleuro-pulmonary disease in patients with SLE: functional and radiological methods. *Egypt J Bronchol* 2024;18:13.
30 Amann M. Pulmonary system limitations to endurance exercise performance in humans. *Exp Physiol* 2012;97:311–8.
31 Mancuso CA, Perna M, Sargent AB, *et al*. A pilot study of office-based spirometry in patients with systemic lupus erythematosus. *Lupus* 2012;21:1343–50.
32 Colwell KL, Bhatia R. Calculated versus Measured MVV-Surrogate Marker of Ventilatory Capacity in Pediatric CPET. *Med Sci Sports Exerc* 2017;49:1987–92.
33 Babak A, Mohamad Reza M, Zahra SB, *et al*. Respiratory muscle function and spirometry in patients with systemic lupus erythematosus. 2006;5:53–8.
34 Worth H, Grahn S, Lakomek HJ, *et al*. Lung function disturbances versus respiratory muscle fatigue in patients with systemic lupus erythematosus. *Respiration* 1988;53:81–90.
35 Przywara-Chowaniec B, Dyrcz D, Bere M, *et al*. Echocardiography and 6-Minute Walk Test for Assessing Disease Progression in Systemic Lupus Erythematosus. *Cardiol Cardiovascmed* 2019;03:221–35.
36 Lee SY, Holloway A, Nikiphorou E, *et al*. POS1506 IDENTIFYING determinants of favourable and poor physical function in systemic lupus erythematosus: results from an international collaborative study. Annals of the Rheumatic Diseases; June 2023 10.1136/annrheumdis-2023-eular.3754 Available: https://doi.org/10.1136/annrheumdis-2023-eular.3754
37 Oeser A, Chung CP, Asanuma Y, *et al*. Obesity is an independent contributor to functional capacity and inflammation in systemic lupus erythematosus. *Arthritis Rheum* 2005;52:3651–9.
38 S S, Nagesh NJ, Suriyan S, *et al*. Correlation of Six Minute Walk Test and Lung Function Test Variables (% FEV1, % FVC, % DLCO) in Patients with Connective Tissue Disorder – Interstitial Lung Disease. *Jemds* 2020;9:2690–4.
39 Eriksson K, Svenungsson E, Karreskog H, *et al*. Physical activity in patients with systemic lupus erythematosus and matched controls. *Scand J Rheumatol* 2012;41:290–7.
40 Sari F, Bayram S, Oskay D, *et al*. Comparison of Exercise Capacity, Physical Activity Level and Peripheral Muscle Strength in Systemic Lupus Erythematosus Patients with Healthy Individuals. *Aktuelle Rheumatologie* 2024;49:264–70.
41 Legge A, Blanchard C, Hanly JG. Physical activity and sedentary behavior in patients with systemic lupus erythematosus and rheumatoid arthritis. *Open Access Rheumatol* 2017;9:191–200.
42 Yilmaz-Oner S, Ilhan B, Can M, *et al*. Fatigue in systemic lupus erythematosus: Association with disease activity, quality of life and psychosocial factors. *Z Rheumatol* 2017;76:913–9.
43 Du X, Zhao Q, Zhuang Y, *et al*. Fatigue of systemic lupus erythematosus in China: contributors and effects on the quality of life. *Patient Prefer Adherence* 2018;12:1729–35.
44 Moraleda V, Prados G, Martínez MP, *et al*. Sleep quality, clinical and psychological manifestations in women with systemic lupus erythematosus. *Int J Rheum Dis* 2017;20:1541–50.
45 Wu L, Shi P-L, Tao S-S, *et al*. Decreased sleep quality in patients with systemic lupus erythematosus: a meta-analysis. *Clin Rheumatol* 2021;40:913–22.
46 Usul M, Apaydin Z, Çivi Karaaslan T, *et al*. Sistemik Lupus Eritematozus Hastalarında Pulmoner Fonksiyon, Fonksiyonel Kapasite ve Fiziksel Aktivite: Kesitsel Bir Çalışma. *J Exerc Ther Rehabil* 2026.

Lupus Science & Medicine: first published as 10.1136/lupus-2026-002284 on 2 November 2026. Downloaded from https://lupus.bmj.com on 8 November 2026 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.