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Increased pain sensitivity, postural abnormalities, and functional balance impairment in obstructive lung disease compared to healthy subjects

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ABSTRACT

Background: Recent reports have identified pain as a comorbidity in obstructive lung diseases, but data regarding pain in certain obstructive lung diseases such as COPD and bronchiectasis vs. healthy controls and differences in pain between these chronic lung diseases are limited.
Objectives: The primary aim of this study was to compare pain sensitivity, postural abnormalities, and functional balance in patients with COPD/bronchiectasis vs. healthy controls. The secondary aim was to evaluate differences in these parameters between two different lung diseases (COPD and bronchiectasis).
Methods: Twenty-nine patients with moderate to severe COPD/bronchiectasis and 31 healthy age/gender-matched individuals participated in the study. Pain sensitivity was assessed with an algometer. Postural abnormalities were analyzed from the lateral and posterior view. Functional balance was evaluated using the Timed Up and Go test (TUG).
Results: Significantly more patients reported pain compared to the healthy controls (89.7% vs. 19.4%, respectively) ($p < 0.05$). The pressure pain thresholds of the trapezius and deltoid muscles and pain tolerance of the pectoralis major muscle were significantly lower in patients compared to healthy subjects ($p < 0.05$). Total and posterior posture scores and TUG time were significantly higher in patients compared to the control group ($p < 0.05$).
Conclusions: This study showed that pain perception, severity, and sensitivity are increased in patients with COPD or bronchiectasis compared to the healthy population. These patients also have more severe postural abnormalities and functional balance impairment than the healthy population.
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Introduction

Chronic lung diseases such as chronic obstructive pulmonary disease (COPD), cystic fibrosis (CF), asthma, and bronchiectasis are characterized by several common symptoms including dyspnea, fatigue, cough and reduced quality of life, and the prevalence of symptoms increases with age.[1] In addition, recent reports have identified pain as a comorbidity.[2,3] Patients with COPD have highly variable prevalence and severity of pain symptoms.[4–6] In a systematic review of 9 studies, the prevalence of pain in moderate to very severe COPD was 66%.[7] Common areas of pain include the lower back/lumbar spine, upper-middle back/thoracic spine, neck/cervical spine, and chest.[2,3,6,8,9] Non-pleuritic chest pain is common in patients with bronchiectasis, occurring predominantly with exacerbations.[10]

Increased tone and shortening of the chest wall and upper extremity muscles have been associated with increased respiratory workload. This results in reduced flexibility, soft tissue contracture, and muscle imbalance.[11-13] As a consequence, postural abnormalities may develop in individuals with asthma,[9] CF,[13] and COPD.[14,15] In turn, posture also has a significant impact on respiratory pattern and ventilation distribution in individuals with COPD.[16]

Functional balance is critical for mobility, reducing the frequency of falls, and maintaining functional independence in daily living activities.[17] Emerging evidence shows that COPD patients have substantial balance deficits.[18–20] Patients with COPD have several risk factors that may lead to balance problems, including muscle weakness, polypharmacy, and polyneuropathy.[21,22] However, there are limited data regarding balance impairment in asthma,[23] and none in other lung diseases such as bronchiectasis.

Although prior studies have compared pain, postural abnormalities, and balance between COPD and healthy subjects,[2,20,24–26] there are limited studies comparing the degree of change in pain threshold and tolerance, postural abnormalities, and balance impairment in patients with COPD and those diagnosed with bronchiectasis, and healthy controls. There is also a paucity of data regarding pain

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perception, posture, and balance in bronchiectasis. In addition, most previous studies relied on subjective scales like the Brief Pain Inventory and McGill Pain Questionnaire for pain assessment; very few studies used objective measures such as pain sensitivity.

Therefore, the primary purpose of the present study was to compare pain threshold and tolerance, postural abnormalities, and functional balance in patients with COPD or bronchiectasis and healthy controls. The secondary aim was to evaluate differences in these parameters between two different lung diseases, COPD and bronchiectasis.

Methods

Subjects

Twenty-nine clinically stable patients aged 18–65 years with moderate to severe COPD/bronchiectasis (15 COPD/14 non-CF bronchiectasis) who were referred for pulmonary rehabilitation were included in this cross-sectional study. Patients who had no acute exacerbations in the last 3 months, had no acute pain problems, and were able to walk and cooperate were included. Patients with neurological disease that may affect cognitive state or severe orthopedic disorders that may affect evaluations were excluded. The control group consisted of 31 healthy age- and sex-matched volunteers who participated in response to an advertisement of the study in our department. The inclusion criteria for healthy subjects were the absence of cognitive impairment, systemic diseases, and physical disabilities. Ethical approval was obtained from the Hacettepe University Ethics Committee, and all patients and healthy controls were informed about the study and signed a written informed consent form before participation.

Assessments

The participants' age, height, and weight were recorded, and body mass index (BMI) was calculated. The most recent spirometry data was recorded from their medical records. Comorbidities were assessed with the Charlson Comorbidity Index (CCI).[27]

The participants were questioned about the location and causes of their pain. They rated pain severity as 'mild', 'moderate', 'severe', 'very severe', or 'unratable'. Pain sensitivity was assessed using an algometer (JTECH Medical-Algometer Commander, Salt Lake City, Utah, USA). Pressure pain threshold and tolerance were measured in 3 upper extremity muscles (trapezius, pectoralis major, and deltoid muscles) while patients were seated. The pressure at which the individual first reported pain was recorded as the pressure pain threshold, while the last pressure point at which they could endure the pain was recorded as pressure pain tolerance. Three pain threshold and tolerance measurements (in Newtons) were made for each location and averages of these measurements were used in the statistical analysis.[28]

The severity of postural abnormalities observed in lateral and posterior views was assessed (0 = absent, 1 = mild, 2 = moderate, 3 = severe) and a posture score (excellent: 0–2, very good: 3–4, good: 5–7, fair: 8–11, poor: ≥ 12) was calculated as described by Corbin et al.[29]

Functional balance was evaluated with the Timed Up and Go test (TUG), a simple screening test used to measure the risk of falling among older adults. Participants were asked to stand from a standardized armchair, walk a distance of 3 m at their usual speed, turn, walk back to the chair, and sit down again. The test was performed twice, and the best time (in seconds) was used in the statistical analysis.[30]

Statistical analysis

Data analyses were performed with the Statistical Package for the Social Sciences (version 18.0) for Windows.[31] Normality of distribution was analyzed using visual methods (histograms/probability plots) and the Kolmogorov-Smirnov test. Based on the distribution of each variable, Student's *t*-test or Mann–Whitney test was used in comparisons of patients and healthy subjects. One-way ANOVA was used to compare pectoral pressure pain threshold and lateral posture score between patients with COPD, bronchiectasis, and healthy groups. As the other parameters were not normally distributed, the Kruskal–Wallis test was conducted to compare these parameters between the three groups. Mann–Whitney *U* test was performed to test the significance of pairwise differences using Bonferroni correction to adjust for multiple corrections. An overall 5% type-1 error level was used to infer statistical significance.[32]

Results

Demographic and clinical data pertaining to the study participants are shown in Table 1. Patients had significantly higher BMI and CCI scores than healthy subjects (Table 1). Comorbidities present in the patient group included peripheral vascular disease in 17.2%, connective tissue damage in 13.8%, diabetes mellitus in 13.8%, myocardial infarction in 6.9%, and peptic ulcer disease in 3.4% of the patients.

A significantly higher percentage of patients reported pain than healthy subjects (89.7% and 19.4%, respectively) (Table 2). The distribution of pain locations in the groups is shown in Table 2. In the control group, 9.7% reported headache with unknown causes and 9.7% had low back pain due to muscle and ligament strain. In the patient group, patients reported headache associated with sinus congestion (24.1%), migraine (10.3%), muscle tension (10.3%), sinus congestion and temporomandibular problems (3.4%), fatigue (6.9%), and unknown causes (10.3%). In addition, 82.8% of the patients had muscle-related chest pain, and low back pain was reported due to muscle and ligament strain (55.2%), herniated disc (6.9%), menstruation (3.4%), and scoliosis (3.4%). Middle/upper back pain was reported due to coughing (41.4%), feeling cold and remaining in a fixed position (27.6%), and scoliosis (3.4%). In addition, 48.3% of patients had neck pain associated with mechanical problems. Extremity pain was reported in association with arthritis (20.7%), orthopedic problems (17.2%), corticosteroid use

Table 1
Comparison of pain sensitivity, postural abnormalities and functional balance in patients with COPD/bronchiectasis and healthy controls

Variables	Patients with COPD/ bronchiectasis (n = 29) Mean (SD)	Healthy (n = 31) Mean (SD)	p
Age (years)	56.59 + 8.00	54.35 + 6.81	0.168
Sex (male/female)	10/19	11/20	0.935
BMI (kg/m^2)	28.31 ± 5.05	24.29 ± 2.87	0.001*
FEV_1 (%)	50.67 ± 22.29	–	NA
FVC (%)	66.69 ± 20.04	–	NA
FEV_1/FVC	61.30 ± 13.73	–	NA
PEF (%)	55.92 ± 24.74	–	NA
CCI score	1.90 ± 1.05	0.0 ± 0.0	<0.001[a]
Pain pressure threshold (N)			
Trapezius	49.73 ± 10.75	68.35 ± 21.17	<0.001[a]
Pectoralis	41.78 ± 12.28	44.59 ± 12.48	0.382
Deltoid	39.42 ± 8.98	55.45 ± 16.21	<0.001[a]
Pain pressure tolerance (N)			
Trapezius	107.31 ± 5.92	95.80 ± 22.09	0.302
Pectoralis	100.59 ± 11.66	71.94 ± 30.62	<0.001[a]
Deltoid	107.0 ± 5.41	98.09 ± 18.40	0.503
Postural abnormalities			
Lateral posture score	8.38 ± 2.46	7.06 ± 3.07	0.073
Posterior posture score	6.20 ± 1.63	3.26 ± 2.44	<0.001[a]
Total posture score	14.66 ± 2.54	10.32 ± 4.42	<0.001[a]
Functional balance			
TUG (s)	6.66 ± 2.54	4.52 ± 0.47	<0.001[a]

Abbreviations: BMI: Body mass index, FEV_1: Forced expiratory volume in one second, FVC: Forced vital capacity, PEF: Peak expiratory flow, CCI: Charlson Comorbidity Index, TUG: The Timed Up and Go Test.

* $p < 0.05$, Student *t*-test.

[a] $p < 0.05$, Mann–Whitney *U* test.

Table 2
Distribution of pain locations in patients with COPD/bronchiectasis and healthy controls

Pain location areas	Patients with COPD/ bronchiectasis ($n = 29$) n (%)	Healthy ($n = 31$) n (%)
Headache	19 (65.5)	3 (9.7)
Chest pain	24 (82.8)	0 (0.0)
Lumbago	20 (69.0)	3 (9.7)
Backache	21 (72.4)	0 (0.0)
Extremity pain	14 (48.3)	0 (0.0)
Stomachache	6 (20.7)	0 (0.0)
Neck Pain	14 (48.3)	0 (0.0)

(6.9%), and excessive walking (3.4%). Stomachache was also reported due to gynecological problems (6.9%) gastritis (3.4%), pancreatitis/gallbladder (3.4%), gastroesophageal reflux (3.4%), and unknown causes (3.4%). Pain severity was mild in 16.1% and moderate in 3.2% of the healthy subjects. In the patient group, 48.3% of patients had mild pain and 48.3% had moderate pain.

Comparisons of pain sensitivity, postural abnormalities, and functional balance in patients with COPD/bronchiectasis and healthy controls are presented in Table 1. Pressure pain threshold of the trapezius and deltoid muscles and pain tolerance of the pectoralis major muscle were significantly lower in the patients compared with healthy subjects (Table 1). Total (lateral + posterior) and posterior posture scores were significantly higher in the COPD/bronchiectasis group compared with control group (Table 1). In the patient group, 86.2% of the patients had poor posture and 13.8% had fair posture. In the healthy control group, posture was assessed as poor in 41.9%, fair in 25.8%, good in 25.8%, very good in 3.2%, and excellent in 3.2% of the subjects. Patients had significantly worse posture than the healthy participants ($p = 0.005$). In addition, the patients had significantly higher mean TUG time compared to healthy controls (Table 1).

Table 3 shows comparisons of pain sensitivity, postural abnormalities, and functional balance in the COPD patients, bronchiectasis patients, and healthy participants. There were significant differences among the groups in terms of trapezius and deltoid pressure pain threshold, pectoral and deltoid pressure pain tolerance, TUG time, and posterior and total posture scores.

After Bonferroni correction, the COPD patients had significantly lower trapezius and deltoid pressure pain threshold and pectoral pressure pain tolerance, and significantly higher TUG times and posterior and total posture scores compared to the healthy group (Table 3). The bronchiectasis patients also showed significantly lower trapezius and deltoid pressure pain thresholds and trapezius pressure pain tolerance, and significantly higher TUG time and posterior and total posture scores compared to the healthy group (Table 3). There were no statistically significant differences in pain sensitivity, postural abnormalities, or functional balance between patients with COPD and patients with bronchiectasis (Table 3, $p > 0.05$).

Discussion

The main findings of our study are that patients with COPD/bronchiectasis have lower pressure pain threshold and tolerance compared to healthy controls. In addition, posture and functional balance are negatively affected in patients with COPD/bronchiectasis. The present study is the first to evaluate pressure pain threshold and tolerance with an algometer and to assess functional balance in bronchiectasis compared to healthy subjects and patients with COPD. This is also the first study to investigate pain sensitivity, postural abnormalities, and balance together in these patient groups.

Pain prevalences ranging from 32 to 60% have been reported in high-quality studies of COPD.[33] In a study including 100 COPD patients with and without pain and 333 healthy individuals with pain, the COPD patients reported pain more frequently than the general population (45% vs. 34%; $p = 0.02$), but there were no differences in pain intensity scores or number of pain locations. The COPD patients noted moderate to severe pain primarily in the chest, shoulders, neck, and thorax.[6,34] HajGhanbari et al. showed that people with COPD demonstrate more pain, greater pain-related interference in their lives, and more fear of movement than healthy people. It has been shown that number of comorbidities was correlated with pain in patients with moderate to severe COPD.[2]

Pulmonary exacerbations are key events in the natural course of bronchiectasis that can worsen symptoms like cough, sputum volume and/or consistency, sputum purulence, and breathlessness. The potential impact of comorbidities on bronchiectasis and vice versa includes provoking acute exacerbations, interfering with acute and chronic pharmacotherapy and rehabilitation for the comorbid conditions, and contributing to progression of chronic disease.[35]

In our previous study, moderate/severe COPD patients were found to have higher pain intensity than their healthy peers. The most common pain locations were the neck and chest.[6,36] Johansson et al.[25]

Table 3
Comparison of pain sensitivity, postural abnormalities and functional balance in patients with COPD, bronchiectasis and healthy controls

Variables	COPD Mean (SD)	Bronchiectasis Mean (SD)	Healthy Mean (SD)	COPD vs controls p	COPD vs controls p	Bronchiectasis vs controls p	COPD vs bronchiectasis p
Pain pressure threshold (N)							
Trapezius	49.52 ± 7.39	49.95 ± 13.78	68.35 ± 21.17	<0.001[a]	<0.001[b]	0.001[b]	0.652[b]
Pectoralis	44.08 ± 11.96	39.30 ± 12.57	44.59 ± 12.48	0.402[*]			
Deltoid	40.27 ± 7.35	38.50 ± 10.68	55.45 ± 16.21	<0.001[a]	0.001[b]	0.001[b]	0.561[b]
Pain pressure tolerance (N)							
Trapezius	106.00 ± 6.46	108.71 ± 5.13	95.80 ± 22.09	0.578			
Pectoralis	98.67 ± 12.79	102.64 ± 10.38	71.94 ± 30.62	0.001[a]	0.005[b]	0.003[b]	0.377[b]
Deltoid	108.80 ± 4.55	105.07 ± 5.74	98.09 ± 18.40	0.080			
Postural abnormalities							
Lateral posture score	8.20 ± 2.40	8.57 ± 2.59	7.06 ± 3.07	0.191[*]			
Posterior posture score	6.27 ± 1.94	6.14 ± 1.29	3.26 ± 2.44	0.001[a]	<0.001[b]	<0.001[b]	0.949[b]
Total posture score	14.60 ± 2.69	14.71 ± 2.46	10.32 ± 4.42	0.001[a]	<0.001[b]	0.001[b]	0.949[b]
Functional balance							
TUG (s)	6.95 ± 1.32	6.34 ± 0.70	4.52 ± 0.47	0.001[a]	<0.001[b]	<0.001[b]	0.270[b]

Abbreviations: TUG: The Timed Up and Go Test.
[*] $p > 0.05$, One-way ANOVA test.
[a] $p < 0.05$, Kruskal–Wallis test.
[b] Bonferroni correction with Mann–Whitney U test for pair wise comparison between groups.

reported lower pressure pain thresholds in patients with sensory hyperreactivity, COPD, and asthma compared to healthy subjects. In our study, we measured pressure pain threshold and tolerance in the upper extremities using an algometer, which is a semi-objective method for quantifying pain and has good reliability and reproducibility.[37,38] Consistent with the literature, the prevalence of pain was higher among COPD/bronchiectasis patients than healthy controls in the present study (89.7% vs. 19.4%). Few studies have utilized objective pain assessments in patients with lung disease. The patients with moderate/severe COPD or bronchiectasis in our study had comorbidities that may increase pain perception, such as peripheral vascular disease, connective tissue damage, and peptic ulcer disease.[7,33–35,39]

Males with COPD have been shown to have more elevated scapulae in comparison to controls, which could lead to pain in the scapular and cervical regions.[14] We also observed unfavorable postural abnormalities in our patients which can cause excessive musculoskeletal strain and trigger pain.[14,40] Most of the pain locations observed in our study (chest, lumbar region, neck) were consistent with the literature.[6,34,36,39] We also showed that the pressure pain thresholds of the trapezius and deltoid muscles and the pain tolerance of the pectoralis major muscle were significantly lower in COPD/bronchiectasis patients when compared with healthy control subjects. Although the mechanism is not clear, this may be related to upregulation of the sensory nervous system.[25]

To the best of our knowledge, our study is the first to compare pain sensitivity between patients with COPD and bronchiectasis. There are limited data regarding pain in bronchiectasis.[10,41,42] The similarity in pain sensitivity between patients with bronchiectasis and COPD in our study may be attributable to their comparable degrees of obstruction and the pain-related effects of common factors like exacerbations, systemic inflammation, coughing, and upregulation of the sensory nervous system.[33,10]

In a systematic review of postural changes in lung diseases published in 2017, increased thoracic kyphosis or scoliosis was reported in both children and adults with CF. While shoulder protraction and elevation were more evident in asthma and COPD, changes in spinal curvature were variable.[43] Morais et al. found that patients with COPD had a more forward head position at maximal protraction, greater head mobility, and smaller range of shoulder flexion than controls. They concluded that muscle length and mobility adaptations may have a role in impaired pulmonary function in COPD.[24]

There are limited data in the literature about the extent of posture alterations in patients with COPD/bronchiectasis.[43] In our study, we evaluated patients and healthy subjects with the clinically practical, observational method previously described by Corbin et al.[29] Overall, patients with COPD/bronchiectasis had higher posterior and total postural abnormality scores than healthy controls due to probable postural misalignments in the lateral and posterior planes (e.g. scoliosis, kyphosis). Severity of postural disturbances was also significantly higher among the COPD/bronchiectasis patients than the controls (posture was evaluated as poor in 86.2% vs. 41.9%, respectively). Although there are trials that evaluate postural changes in asthma[9] and COPD[23] compared to controls, we believe the present study is the first to compare the postural abnormalities of bronchiectasis patients with those of healthy control or COPD groups. Our comparison suggests that COPD and bronchiectasis have a similar influence on posture. This may also be attributable to the comparable obstruction severity in the groups and similar acquired posture associated with lung hyperinflation, coughing, changes in respiratory mechanics, and accessory muscle use.

Studies have shown that people with COPD generally have impaired balance. Although the underlying mechanisms remain unclear, there is evidence of a relationship between systemic inflammation and balance deterioration.[18,20] In addition, age-related changes have an especially deleterious effect on balance.[44] Numerous studies have assessed balance in COPD[20,26,45] and asthma[23] in comparison to controls, but this topic has not been investigated in bronchiectasis. Our study has shown for the first time that patients with bronchiectasis have greater functional balance impairment than healthy controls. However, our results indicate similar balance impairment in COPD and bronchiectasis. This may be due to the fact that both conditions involve inflammatory processes that lead to muscle weakness, decreased oxygenation level, and reduced functional capacity.

This study has several limitations. We did not include other obstructive lung disorders such as asthma and cystic fibrosis. These individuals are typically younger and likely to have different symptom profiles. We were unable to assess postural changes using more objective methods like photogrammetry or Spinal Mouse which provide a measurable numerical outcome. In addition, balance impairment could have been evaluated with more comprehensive methods. We used one of the clinically practical methods for balance assessment. Finally, pain is a difficult symptom to assess because it is multidimensional and has many confounding factors.

Conclusions

In conclusion, this study showed that pain perception, severity, and sensitivity are increased in patients with COPD/bronchiectasis compared to the general population. COPD/bronchiectasis patients also had more severe postural abnormalities and functional balance impairment than the healthy population. Our study shows for the first time that patients with bronchiectasis have increased pain sensitivity, postural abnormalities, and balance impairment compared to healthy individuals, but to a similar extent as COPD patients. Therefore, both COPD and bronchiectasis patients should undergo comprehensive assessment in pulmonary rehabilitation programs for pain, postural alignment, and balance problems that negatively affect activities of daily living. These parameters may be important outcome measures that can improve our understanding of these patients' symptomatology.

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Supplementary materials

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