Original article

Evaluation of pulmonary function in patients of non-specific low back pain

Avaliação da função pulmonar em pacientes com dor lombar inespecífica

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ABSTRACT | INTRODUCTION: Diaphragm is the primary inspiratory muscle and it plays an essential role in controlling the spine during postural control. In nonspecific low back pain, the diaphragm muscle becomes weak, due to which the pulmonary functions may decrease. To the best of our knowledge there is a scarcity of literature in regard to the effect of low back pain on pulmonary parameters. Thus, the study is aimed to evaluate the pulmonary function in patients with non-specific low back pain. **METHODS:** One hundred and thirteen patients with non-specific low back pain and 113 BMI matched normal individuals as a comparison group aged 18-40 years of male and female genders were recruited by purposive sampling method for this prospective cross-sectional study. The non-specific back pain group included participants diagnosed with non-specific low back pain with pain intensity ≥ 3 on VAS scale and duration ≥ 3 months. After initial screening and assessment, anthropometric characteristics were recorded. Then, the pulmonary function test (FEV_1, FVC, FEV_1/FVC, PEFR, SVC, MVV) were recorded in both groups. **RESULT:** Kolmogorov-Smirnov test was used for normality assessment and data was found to be not normally distributed. Non parametric data was represented as median and IQR (Inter Quartile Range). Between groups data analysis was performed by using Mann-Whitney U test and the effect size was computed for the study variables. $P < 0.05$ was considered as statistically significant. There was a significant difference in pulmonary function values of FEV_1, FEV_1/FVC, PEFR, SVC, MVV. There was no significant difference in age and BMI of the participants of both groups. **CONCLUSION:** There exist significant differences in pulmonary function in patients with non-specific low back pain.

KEYWORDS: Low Back Pain. Lung Function. Respiratory Muscles. Spirometry.

RESUMO | INTRODUÇÃO: O diafragma é o principal músculo inspiratório e desempenha um papel essencial no controle da coluna durante o controle postural. Na dor lombar inespecífica, o músculo diafragma torna-se fraco, podendo as funções pulmonares diminuir. Até onde sabemos, há escassez de literatura a respeito do efeito da dor lombar nos parâmetros pulmonares. Assim, o estudo tem como objetivo avaliar a função pulmonar em pacientes com dor lombar inespecífica. **MÉTODOS:** Cento e treze pacientes com dor lombar inespecífica e 113 indivíduos normais pareados com IMC como grupo de comparação com idades entre 18 e 40 anos, dos gêneros masculino e feminino, foram recrutados por método de amostragem proposital para este estudo transversal prospectivo. O grupo de dor nas costas inespecífica incluiu participantes com diagnóstico de dor lombar inespecífica com intensidade de dor ≥ 3 na escala VAS e duração ≥ 3 meses. Após triagem e avaliação inicial, as características antropométricas foram registradas. Em seguida, foram registrados os testes de função pulmonar (VEF_1, CVF, VEF_1/CVF, PFE, CVL, VVM) em ambos os grupos. **RESULTADO:** O teste de Kolmogorov-Smirnov foi utilizado para avaliação da normalidade e os dados não apresentaram distribuição normal. Os dados não paramétricos foram representados como mediana e IQR (intervalo interquartil). A análise dos dados entre grupos foi realizada pelo teste U de Mann-Whitney e o tamanho do efeito foi calculado para as variáveis do estudo. < 0,05 foi considerado estatisticamente significativo. Houve diferença significativa nos valores de função pulmonar de VEF_1, VEF_1/CVF, PFE, CVL, VVM. Não houve diferença significativa na idade e no IMC dos participantes de ambos os grupos. **CONCLUSÃO:** Existem diferenças significativas na função pulmonar em pacientes com dor lombar inespecífica.

PALAVRAS-CHAVE: Dor Lombar. Função Pulmonar. Músculos Respiratórios. Espirometria.

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1. Introduction

The low back pain (LBP) is one of the largest health problems reported globally.[1,2] Low back pain is a musculoskeletal disorder experienced by 80% - 90% of adults at least once in their lifetime.[2,3] Globally the prevalence of LBP was reported to be 8.20% in 1990 and 7.50% in 2017; prevalence is higher in females than males.[4]

Low back pain is among the top 10 most common high debilitating diseases and injuries with the usual number of disability-adjusted years of life exceeding that of many conditions.[5] When the pathologic cause is known, its referred to as specific low back pain but when the pathological cause of the pain cannot be determined, its known as non-specific low back pain (NSLBP).[5,6] Non-specific low back pain is a major health concern encountered by medical professionals in daily clinical practice.

Altered respiratory characteristics have been reported in patients with NSLBP.[7] Inspiratory muscle plays a most important role in respiration & spinal control.[8,9] The human diaphragm is the primary inspiratory muscle and it play an essential role in controlling the spine during postural control.[7] The diaphragm is an inspiratory muscle that helps in respiration & spinal control and its dysfunction is usually related to the low back pain.[8,9] The diaphragm contributes to trunk stabilization during challenges to postural balance.

The coordinating function of the transversus abdominis and diaphragm is reduced in the case of chronic low back pain.[9] These changes in the body begin as an adaptive breathing strategy, such adaptive strategies would relax the abdominal muscle more than the necessary inspiration.[10] The adaptive breathing pattern can result in more upper chest breathing and less efficient diaphragmatic activity.[10] The decreased mobility of the diaphragm can lead to a decrease in respiratory muscle strength, and may be associated with decreased intra-abdominal pressure in LBP patients.[7]

The diaphragm is the primary inspiratory muscle and it plays an essential role in controlling the spine during postural control. In nonspecific low back pain, the diaphragm muscle becomes weak, due to which the pulmonary functions may decrease. To the best of our knowledge, there is a scarcity of literature in regard to the effect of low back pain on pulmonary parameters. Thus, the study is aimed to evaluate the pulmonary function in patients with nonspecific low back pain and compare it with normal adults.

2. Methods

The study protocol was approved by the ethical committee of the institute with number I.E.C.M.03/2022/06/P07. The study was conducted following the Helsinki Declaration and National Ethical Guidelines for Biomedical and Health Research involving human participants' guidelines laid by the Indian Council of Medical Research (ICMR, 2017).

2.1. Study design and sampling

A prospective cross-sectional was conducted using a purposive sampling method.

2.2. Sample size

The sample size was calculated by using the formula $n= Z\alpha^2 P(1-P)/d^2$ where n stands for the number of participants, Zα is the level of significance set as 1.96, P stands for prevalence and it was set as 7.50% (global prevalence of LBP from previous study)[1], and d is error set as 5%. The estimated sample size was 107. Considering a 5% non-respondent rate (n=6), a sample of 113 was required. Total sample size: 113 non-specific low back pain patients. 113, a comparison group of normal adults.

2.3. Study population

The participants included were males and females with diagnosed nonspecific low back pain aged 18-40 years with a Body Mass Index (BMI) of 18.5 – 29.9 Kg/m^2. The participants were included if they had a score of pain ≥ 3 on 10 cm VAS (visual analog scale) and pain duration ≥ 3 months.

Participants with any history of back surgery, history of any surgery within the last 6 months such as the cardiothoracic, lumbar spine, thoracic and abdominal surgery etc, documented history of cardio-respiratory condition, musculoskeletal, metabolic disorder, neurological condition and immune disorder, history of trauma in last one year, hospitalization in 6 months preceding the study, sprains of costo-chondral, costo-sternal and interchondral joint, previous history of rib/spine fracture, patients on drug therapy which alter spirometry parameters, history of COVID 19 were excluded. Also, active sports person, pregnant females and lactating mothers were excluded.

Comparison group included BMI matched normal adults of male and female gender aged 18-40 years.

Participants meeting the inclusion and exclusion criteria were selected for the study. The low back pain participants were recruited from the physiotherapy OPD of the institute. Healthy adults were recruited from among the students and staff of the university, relatives of the patients and nearby community dwellings. Written consent was obtained from participants prior to the conduct of the study. All the assessment and documentation of the variables were conducted in the physiotherapy OPD of the institute. The assessment and recording of variables was performed by post-graduate cardiopulmonary therapist well-trained in the conduction of the tests.

After screening, the participant's demographic data was collected. Weight and height were measured and BMI was calculated. Weight was measured by a digital weighing machine, and height was measured by a stadiometer. Height and weight were measured without shoes, standing with feet together, as tall as possible with eyes at the same level and looking straight ahead.

2.4. Assessment of pulmonary function

Spirometry was used to perform the pulmonary function tests using a spirometer (RMS Helios 702) according to the recommendations of the standardized guidelines.[11,12] Three technically acceptable and reproducible forced expiratory curves were obtained for each participant. Variability between them was <5%, and only the curve with the best performance was considered for analysis. SVV was also performed following standardized guidelines. For the MVV, the participants were instructed to maximize ventilation by inhaling and exhaling as quickly and deeply as possible for 15 seconds, and values were expressed in liters per minute.

Variables: Pulmonary function: FEV_1, FVC, FEV_1/FVC (%) ratio, PEFR, SVC, and MVV

2.5. Statistical Analysis

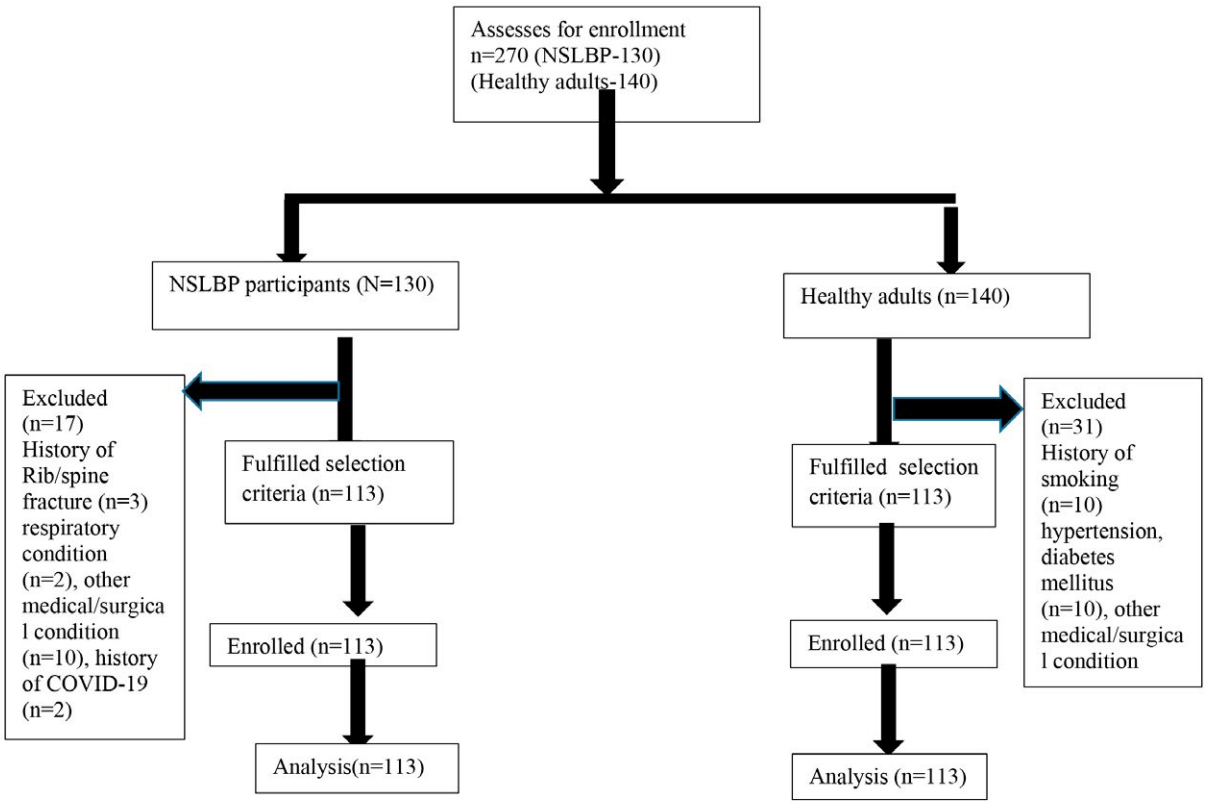
Data was analyzed using IBM Statistical Package for Social Sciences (SPSS) Statistics 28.0 version. To assess the normality of the data, the Kolmogorov-Smirnov test was used. As data did not follow normal distribution, non-parametric test was applicable. Non-parametric data was represented as median and IQR (Inter Quartile Range). Between groups data analysis was performed by the Mann-Whitney U test. In addition, the effect size was computed for the study variables. The interpretation of effect size was estimated based on previously published guidelines.[13,14] P value <0.05 was considered statistically significant.

3. Results

All the enrolled participants (N=226, 112 males and 114 females) completed the test, and there were no dropouts. The study flowchart is shown in Figure 1. The median (IQR) VAS score for the population (n=113) is reported 6(1) and median duration of pain was 7(2).

In the present study, spirometry variables FEV_1, FEV_1/FVC, PEFR, SVC, and MVV were significantly less in males and females with NSLBP group and there was no change in FVC.

Figure 1. Study flowchart



Source: the authors (2023)

All 226 participants completed the present study without any dropouts. The characteristics of the study population are summarised in Table 1. There was no significant difference in BMI between the non-specific low back pain group and normal adult group participants (p= 0.139).

Table 1. Demographic Characteristics of participants of both groups

Characteristics N=226	**Median (IQR) N=226**	**NSLBP Median (IQR) N=113**	**Comparison group Median (IQR) N=113**
AGE (years)	24(5)	24(6)	24(5)
WEIGHT (Kg)	58(17)	57.6(17.5)	60(14.50)
HEIGHT (cm)	162(16)	162(16)	165(15)
BMI (Kg/m^2)	22.1(4.3)	21.64(4.18)	22.86(3.85)

NSLBP - Nonspecific Low Back Pain, BMI-Body Mass Index; IQR- Inter Quartile Range.
Source: the authors (2023).

There were significant differences in values of FEV_1, FEV_1/FVC, PEFR, SVC and MVV between nonspecific low back pain group and normal adult group participants (Table 2). The FEVI, FEV_1/FVC, PEFR ($P < .05$) values were lower in the NSLBP group when compared to healthy individuals, with a small effect size (0.49, 0.36, 0.41 respectively). This indicated that the respiratory parameter decreased in the LBP group. In contrast, FVC values were not significant between the two groups ($P > 0.05$), with an effect size of 0.34. Nevertheless, there were statistically significant values of SVC ($P < 0.05$) with a moderate effect size (0.59) and MVV ($P < 0.05$) with a large effect size (1.17).

Table 2. Between Group Comparisons of Pulmonary Functions

Pulmonary Function	NSLBP Group Median (IQR)	Normal Adults Group Median (IQR)	Z value	p-value
FEV_1 (Litre)	2.47(0.83)	2.68(1.12)	-3.38	<0.001*
FVC (Litre)	2.70(0.92)	2.96(1.18)	-2.58	0.10
FEV_1/FVC (%)	93.53(10.51)	95.01(7.90)	-2.05	0.040*
PEFR (Litre/Min)	5.13(1.93)	5.52(2.21)	-2.80	0.003*
SVC (Litre)	2.59(0.79)	3.10(1.26)	-3.81	<0.001*
MVV (Litre/min)	44(21.5)	67(34)	-7.92	<0.001*

NSLBP - Nonspecific Low Back Pain; FEV_1 - Forced Expiratory Volume in 1 Second; FVC - Forced Vital Capacity; PEFR - Peak Expiratory Flow Rate; SVC - Slow Vital Capacity; MVV - Maximal Voluntary Ventilation.
*p-value < 0.05 is considered significant.
Source: the authors (2023).

There's gender differences in the pulmonary parameters of NSLBP patients as shown in Table 3.

Table 3. Gender wise Comparison of Pulmonary Parameters in NSLBP Group

Pulmonary Variables	Male Median (IQR) N=112	Female Median (IQR) N=114	Z value	P-Value
FEV_1 (Litre)	3.02(0.48)	2.24(0.13)	-7.44	<0.001*
FVC (Litre)	3.42(0.71)	2.41(0.55)	-7.19	<0.001*
FEV_1/FVC %	93.56(8.7)	92.24(10.82)	-0.74	0.460
PEFR (Litre/Min)	5.5(1.95)	4.90(1.83)	-3.04	0.002*
SVC (Litre)	3.51(0.70)	2.26(0.51)	-7.81	<0.001*
MVV (Litre/min)	50(22.75)	40(20)	-3.17	0.002*

NSLBP - Non-Specific Low Back Pain; FEV_1 - Forced Expiratory Volume in 1 Second; FVC - Forced Vital Capacity; PEFR - Peak Expiratory Flow Rate; SVC - Slow Vital Capacity; MVV - Maximal Voluntary Ventilation, IQR - Inter Quartile Range.
*p-value < 0.05 is considered significant.
Source: the authors (2023).

4. Discussion

The study findings indicate that individuals with NSLBP exhibit alteration in pulmonary function compared to normal adults. The result showed significant changes in pulmonary functions like FEV_1, FEV_1/FVC, PEFR, SVC, and MVV. The main possible cause for the observed alteration in pulmonary function is the pain-induced inhibition of the diaphragm, the primary muscle responsible for breathing. The pain and accompanying muscle guarding may lead to the reduced excursion of the diaphragm, resulting in reduced pulmonary functions.[1] Additionally the altered movement patterns and postural adaptation are commonly seen in individuals with NSLBP.[1]

All 226 participants completed the present study without any dropouts. The selection criteria were appropriate based on the previous studies.[7,9] The participants in both groups were of the same BMI category.

Maximum Voluntary Ventilation (MVV) is the maximum amount of air that voluntarily enters and leaves the lungs in one minute.[15] In the present study, there was a significant difference in MVV values in NSLBP patients as compared to normal adults The results of our study are in agreement with the study of Mohan et al.[7] and Mohanty et al.[9]

MVV represents respiratory muscle activity and strength. The large effect size obtained for MVV indicates that it is altered to a greater extent in NSLBP patients. It has been proposed that alveolar carbon dioxide clearance in NSLBP may affect by respiratory muscular endurance and alter diaphragmatic mobility. The diaphragm and transversus abdominis are thought to work together to maintain body stability and show structural changes in NSLBP patients.[16] Evidence also suggests that the function of the fascia of the lumbar spine is also affected in LBP patients. The transversus abdominis and thoracolumbar fascia can limit the biomechanics of the diaphragm and other respiratory capacities and mechanics. The fascia sends contraction forces in all directions, strengthening the muscles.[16] MVV values were found lower in the NSLBP group than in healthy individuals. MVV is an indicator of airway pressure, respiratory muscle tone, lung-chest wall compatibility, and airway management.

In this present study, there was a significant difference in SVC values in NSLBP patients as compared to normal adults. Regarding the effect on pulmonary function in low back pain patients on this parameter, no study could be found in the literature.

In the present study, the median values of FEV_1 of NSLBP patients were significantly less as compared to the normal adults. This could be associated with core muscle weakness and pain as it is directly affected by respiratory muscle weakness and spinal instability due to the muscle weakness, particularly the transversus abdominis and multifidus.[16] Biomechanically, this muscle has 2 main respiratory functions, first pulling the rib cage from their sides and second increasing intra-abdominal pressure. Failure of this process changes the ability to generate effective respiratory energy and ultimately leads to pulmonary condition due to the plasticity of tissue. Weakness of respiratory muscles can affect the maximum airflow to fill the lungs, resulting in poor performance during exhalation.[17-19] The decline of FEV_1 in the low back pain patient group in the present study is in agreement with the study of Kim et al.[3] and Mohan et al.[7]

The reduction in FEV_1 is attributed to abdominal muscle weakness in chronic low back pain patients.[3] The reduction is also attributed to the instability, fatigue, and abnormal position of the diaphragm and postural dysfunction in NSLBP patients.[7,20] Also reduction in FEV_1 is attributed to the weakness of back flexors and back extensors and intensity of the pain.[21] The stabilizing part of the lumbar spine is made by the transversus abdominis.[22] During the breath, transversus abdominis work with the internal oblique muscles and external oblique muscles to stabilize the lumbar spine. The transversus abdominis muscle, together with the lumbar multifidus muscle, plays an important role in stabilizing the lumbar spine.[23] It has been shown that during inspiration, the transversus abdominis muscles receive more activity than the other abdominal muscles.[24] Likewise, has more activity during exhalation compared to other muscles, such as the transversus muscle, rectus abdominis, and the internal and external oblique muscles.[25] Core muscle weakness and trunk muscle weakness can cause impaired respiratory function in low back pain.[26]

FVC is the amount of air that can be forcefully exhaled from our lungs after taking a possible deepest breath. It's a very important function in pulmonary function tests.[15] The FVC values were found to be less in the NSLBP group though; there was no significant difference between groups. However, the results are not in line with the study by Mohanty et al.[9] They proposed that the abdominal muscle prepares the diaphragm for the next inspiration at the end of expiration, and if changes occur in the abdominal muscles or recruitment, deep inspiration may be affected, which may be the cause of the decrease in FVC.[9] Lung function peaks in the early 20s, stay there for a while, and naturally declines with age[27] and all our participants were 18-40 years of age.

FEV_1/FVC is the amount of air exhaled in the first second is a direct ratio of FVC. FEV1/FVC allows for the separation of obstructive and restrictive disease patients. There was a significant change in FEV1/FVC in the patients with NSLBP patients in comparison to normal adults in the present study.

Peak Expiratory Flow Rate (PEFR) is an assessment method of the ventilatory capacity with one breath.[15] In the present study, there was a significant difference in PEFR value in NSLBP patients as compared to normal healthy adults. Soundararjan et al.[21] also observed a similar reduction in PEFR in NSLBP patients. They proposed that reduced PEFR may be because of core muscle weakness in prolonged back pain, along with the pain and kinesiophobhia associated with chronic LBP.[21] On the other hand, weakness of the respiratory muscles also reduces the capacity of the lungs, which leads to reduced lung capacity and thus poor health.[19] Pain can alter body control patterns by reducing muscle contraction in musculoskeletal problems and similarly, fear of movement (kinesiophobia) can prevent spinal movement.[28]

In the present study, spirometry variables FEV1, FVC, PEFR, SVC, and MVV were significantly less in males and females with the NSLBP group and there was no change in FEV1/FVC. Possible explanations for gender differences include differences in lung geometry between genders.[29]

The reduction rates of FVC and FEV1 increase with increasing age, but they do not display a linear reduction and the reduction rates are faster in men than in women.[28]

The PEFR reaches its peak at the age of approx. 30-35 years and subsequently decliner particularly after age of 40. PEFR reduces at the rate of 4 L/min/year in men and 2.5 L/min/year.[28] Respiratory muscle strength decreases with age and much more so in men than women.[27] Also, the females are more involved in tasks such as bending which is a common factor involved for the cause of lower back pain.[30]

This study has direct implications for health-care professionals dealing with individuals with NSLBP. There have been various management of patients with low back pain[31,32]; however, there is the least emphasis on the respiratory characteristics of these patients. There exist changes in pulmonary parameters in NSLBP patients. Thus, doing stabilization exercises alone will not increase the activation of transversus abdominis and multifidus muscle in patients with low back pain. Thus, there is a need for early screening of the low back pain population for deterioration of pulmonary parameters as a preventive strategy. Hence, there is a need to incorporate respiratory muscle training to prevent deterioration in lung function.

There were a few limitations of the study: the study was single-centred and participants greater than 40 years of age were not recruited due to physiological changes that occur with aging. Thus, multi-canter studies should be conducted with varied age groups for cross-cultural comparison.

5. Conclusion

When compared to healthy participants, the outcomes of this study revealed a change in pulmonary function in non-specific low back pain patients. As a preventative measure, early screening of the non-specific low back pain population for worsening of pulmonary parameters is required in clinical settings. Outcomes for non-specific low back pain patients can be improved by addressing the factors investigated in this study

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Authors' contributions

Uddin B designed the experiments, collected the data, and wrote the manuscript. Vaish H designed the experiment, analyzed the data, contributed with critical intellectual content, and wrote the manuscript.

Conflicts of interest

No financial, legal, or political conflicts involving third parties (government, private companies, and foundations, etc.) were declared for any aspect of the submitted work (including but not limited to grants and funding, advisory board participation, study design, manuscript preparation, statistical analysis, etc.).

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