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Role of Diaphragmatic Intervention and its Effects on Lumbago in Persons with Breathing Dysfunction: A Randomized Control Trial

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Abstract: ***Background: Non - specific low back pain commonly defined as low back pain or lumbago, not regarded, caused and recognized by known distinct pathology. In lumbago, the symptoms are pain confined beneath the costal margin and above the inferior - gluteal folds, decreased spine range of motion, reduced strength of muscles and functional abilities of lower back due to altered mechanics of lumbar spine, apart from which breathing dysfunction is commonly seen. The influence of diaphragmatic intervention to improve non - specific low back pain is lacking. The effectiveness of doming of diaphragm technique to improve non - specific low back pain is unclear. Hence, we intend to study the effectiveness of doming of diaphragm technique along with diaphragmatic breathing in patients with lumbago. Methods: 40 subjects were selected and randomly distributed into 2 groups. Outcome measures included Numerical pain rating scale (NPRS), Lumbar ROM, Lumbar stability, Modified Oswestry Disability questionnaire (mODI) and Diaphragm thickening fraction (DTF). Control group received Conventional therapy exercises and Experimental group received Diaphragmatic intervention exercises. The outcome measures were assessed on day 1 of 1st week and last day of 4th week. Paired t - test was done for intra group analysis and Independent t - test was done for inter - group analysis. Results: The results indicated that conventional therapy and diaphragmatic intervention significantly decreased pain, improved diaphragm muscle thickening fraction, increased the flexibility and stability of spine and improved functional disability at the end of four week treatment program. Conclusion: Both the groups showed significant effect on lumbago in all the outcome measures. Doming of diaphragm technique in combination with diaphragmatic breathing is effective in patients with lumbago. No significant difference was found between the control and the experimental group.***

Keywords: Lumbago, Non - specific low back pain, Diaphragmatic intervention, Diaphragmatic doming

1. Introduction

Lumbago or low back pain is nearly a universal experience among the adult population. Studies have estimated the incidence of low back pain to be 15% in adults and point prevalence to be 30% (1). Normal breathing pattern known as costodiaphragmatic breathing involves both diaphragmatic and upper chest breathing, in which the diaphragm first creates abdominal movement followed by the movement of the ribcage (2). Any deviation from normal breathing leads to dysfunctional breathing, of which the commonly observed patterns in lumbago are paradoxical breathing, upper costal breathing and the mixed patterns (3). Studies have been conducted to determine the effects of diaphragm stretching on posterior chain kinematics and rib cage mobility (4). Doming of diaphragm technique helps in restoration of normal function of the diaphragm by relaxing the resting state of diaphragm, alleviating the contraction and relaxation function of the muscle, thereby increasing the mobility and creating a greater pressure gradient between abdomen and thorax, and thereby improving its function (5). Diaphragmatic breathing is exceptionally effective on pain. It has a major influence on relaxing the muscles which tense up as a result of pain and in turn further aggravate the pain itself. Individuals with tensed muscles and in an anxious state of mind are generally known to breathe through their chest which leads to a disruption of the balance of oxygen and carbon dioxide, which are essential to be in a relaxed state. It is this state of health that the correct technique of diaphragmatic breathing facilitates (6). Measurement of diaphragm thickness using B - mode Ultrasound has the capacity to be used as biofeedback apparatus in identification of diaphragm dysfunction in patients with lumbago having abnormal diaphragm movement and less diaphragm excursion with loading activities (7). In lumbago, the symptoms are pain confined beneath the costal margin and above the inferior - gluteal folds, decreased spine range of motion, reduced strength of muscles and functional abilities of lower back due to altered mechanics of lumbar spine, apart from which breathing dysfunction is commonly seen. Physical therapists rank the core stabilization exercises as the most useful approach for managing patients with lumbago. Various physiotherapy treatment options include traction, stretching, taping, strengthening exercises, heat application, and modality like Interferential therapy, short wave diathermy but with varying degree of success. But no single intervention has been proven to be most efficient. However, the influence of diaphragmatic intervention to improve non - specific low back pain is lacking. To date, information on the effectiveness of doming of diaphragm

technique to improve non - specific low back pain is unclear. Hence, we intend to study the effectiveness of doming of diaphragm technique along with diaphragmatic breathing in patients with lumbago.

2. Methods and Study Design

40 subjects with non - specific low back pain were randomly allocated from Physiotherapy outpatient department, Nizam's Institute of Medical Sciences, Hyderabad, India, into control group and experimental group by simple random sampling using even - odd method. Pre intervention and post intervention measurements are blinded. There is no interaction between the subjects. Diagnosis was made initially by the referring physician and confirmed by the physiotherapist who performs the initial examination. The allocations were concealed from the principal investigator. The outcome measures were single blinded and were taken by a physical therapist who was trained in taking the outcome measures. Informed consent was obtained from patient who met the criteria.

Inclusion criteria: Subjects diagnosed with lumbago having breathing dysfunction, Pain with non - specific origin, Symptoms induced with movement, age group of 18 - 65 years, both male and female, Numerical Pain Rating Scale (NPRS) less than 7.

Exclusion criteria: Spinal fractures or surgeries, inflammatory or specific disorders of the spine such as Ankylosing spondylitis, Paget's disease, Rheumatoid arthritis etc., disc diseases, lumbar radiculopathy, thoracic or abdominal surgeries, pathology of hip/knee/ankle, patient with known pregnancy, severe pain (NPRS > 7), red flags such as cancer, trauma, constitutional symptoms (Fever, Malaise, Weight Loss), recent infection.

Outcome measures included Numerical pain rating scale (NPRS), Lumbar ROM, Lumbar stability, Modified Oswestry Disability questionnaire (mODI) and Diaphragm thickening fraction.

Procedure: Baseline measurements of Numerical pain rating scale (NPRS) for back pain intensity, lumbar ROM using measurement tape, lumbar stability using pressure biofeedback unit, back specific disability score - Modified Oswestry disability index (mODI) and diaphragm thickening fraction (DTF) using diagnostic ultrasound machine were taken on the 1st day. In control group, subjects were taught conventional physiotherapy exercises on 1st day and were advised to perform the exercises as the dosages mentioned. For experimental group, six contact sessions were given at 24 hr interval in the 1st week. In 2nd and 3rd weeks, a home - based exercise program was prescribed, and four contact sessions were given (two sessions per week). During 4th week, home program was taught to the patients to be continued for the week. At the end of session (1st day), the subjects were assessed for any increase in pain. If, no, adverse response was reported, further sessions were carried out. At the end of 4th week, final readings of all outcome measures were taken and data analysis was done for final results.

Group 1 Control Group:
Received conventional therapy exercises. Dosage: 2 sets X 10 repetition with 2 mins rest between each set, daily for 1st week, twice for 2 - 3 weeks, home program for 4th week.

Group II Experimental Group
Received diaphragmatic intervention exercise (doming of the diaphragm technique and diaphragmatic breathing exercise). Dosage: 2 sets with 2 mins rest between each set, daily for 1st week, twice for 2 - 3 weeks, home program for 4th week.

3. Results

At the end of the study, 4 subjects went for drop out. Out of 36 subjects who completed the study, 25 subjects were between age group of 21 - 30 yrs, 6 subjects between age ranging 31 - 40 yrs, 2 subjects with age between 41 - 50 yrs and 3 subjects with age more than 50 yrs. Out of 36 subjects, 25 subjects were females and 11 subjects were male. Based on BMI, 21 subjects were categorized to have normal BMI, 11 subjects were overweight, 3 subjects were underweight and 1 subject was under obese class I category. Waist - hip ratio was calculated for all subjects and it was found that 29 subjects (which included both males and females of any age group) were at low risk, 3 subjects were at moderate risk and 4 subjects were at high risk of developing serious health issues. After looking at the breathing pattern, it was observed that 18 subjects had thoraco - abdominal breathing pattern, 17 subjects showed upper costal breathing pattern and 1 subject had paradoxical type of breathing. Both the groups were assessed for Numerical pain rating scale (NPRS) for back pain intensity, lumbar ROM using measurement tape, lumbar stability using pressure biofeedback unit, diaphragm thickening fraction (DTF) using diagnostic ultrasound machine, back specific disability score - Modified Oswestry disability index (MODI). All the parameters were measured at baseline day 1 and the end of 4th week, following the completion of intervention for 36 subjects with 18 subjects in control group, 18 subjects in experimental group successfully. At the end of 4th week, 4 dropouts (2 in control group and 2 in experimental group 2). The drop outs were made because of personal and financial reasons. The data was collected and statistical analysis was done successfully.

Numerical Pain Rating Scale (NPRS): Pain has reduced in two groups evident by the mean values of NPRS as shown in Table1. a. A statistical analysis was done to observe intra - group variation using paired T - test.

Table 1 (a): Comparison of pretest and posttest NPRS scores in control and experimental groups by paired t - test.

Variable	Group	N	Mean		SD		Mean diff	t	p - value
			pre	post	pre	post			
NPRS	Control	18	6.78	1.28	0.428	0.958	5.5	21.249	0.000
	experimental	18	6.78	1.67	0.428	1.237	5.111	15	0.000

An independent T - test was done to statistically analyze the inter - group variance. There was no significant difference among control group and experimental group on day 1 and at end of 4thWeek as seen in Table1. b.

Table 1 (b): Comparison of intergroup NPRS scores of pretest and posttest by independent t - test

	t - test for equality of means		
		T	P (2 - tailed)
NPRS - pre	Equal variances assumed	0.00	0.00
NPRS - post	Equal variances assumed	1.005	0.299

Hence there is significant improvement in pain reduction in control and experimental group from day 1 to end of 4th week but no significant improvement in intergroup analysis.

Lumbar range of motion (ROM) - Flexion: Flexion range of lumbar spine has improved in two groups evident as shown in Table2. a. A statistical analysis was done to observe intra - group variation using paired T - test.

Table 2 (a): Comparison of pretest and posttest lumbar flexion scores in control and experimental groups by paired t - test

Variable	group	N	Mean		SD		Mean diff	t	p - value
			Pre	post	pre	post			
Lumbar flexion	Control	18	4.56	6.72	1.653	1.638	- 2.167	- 5.442	0.000
	experimental	18	4.78	6.56	1.734	1.542	- 1.778	- 7.114	0.000

An independent T - test was done to statistically analyze the inter - group variance. There was no significant difference among control group and experimental group on day 1 and at end of 4thWeek as seen in Table2. b.

Hence there is significant improvement in flexion range of motion in control and experimental group from day 1 to end of 4th week but no significant improvement in intergroup analysis.

Table 2 (b): Comparison of intergroup lumbar flexion scores of pretest and posttest by independent t - test

	t - test for equality of means		
		T	P (2 - tailed)
Lumbar flexion - pre	Equal variances assumed	- 0.394	0.696
Lumbar flexion - post	Equal variances assumed	0.314	0.755

Lumbar range of motion (ROM) - Extension: The findings of the present investigation indicate that extension range of lumbar spine has improved in two groups evident as shown in Table3. a. A statistical analysis was done to observe intra - group variation using paired T - test.

Table 3 (a): Comparison of pretest and posttest lumbar extension scores in control and experimental groups by paired t - test

variable	group	N	Mean		SD		Mean diff	T	p - value
			pre	post	pre	post			
Lumbar extension	Control	18	2.61	2	0.778	0.242	0.611	3.335	0.004
	experimental	18	2.67	2.06	0.594	0.236	0.611	4.267	0.001

An independent T - test was done to statistically analyze the inter - group variance. There was no significant difference among control group and experimental group on day 1 and at end of 4thWeek as seen in Table3. b.

Hence there is significant improvement in extension range of motion in control and experimental group from day 1 to end of 4th week but no significant improvement in intergroup analysis.

Table 3 (b): Comparison of intergroup lumbar extension scores of pretest and posttest by independent t - test

	t - test for equality of means		
		T	P (2 - tailed)
Lumbar extension - pre	Equal variances assumed	- 0.241	0.811
Lumbar extension - post	Equal variances assumed	- 0.566	0.575

Lumbar range of motion (ROM) - Right lateral flexion: Right lateral flexion range of lumbar spine has improved in two groups evident as shown in Table4. a. A statistical analysis was done to observe intra - group variation using paired T - test.

Table 4 (a): Comparison of pretest and posttest lumbar right lateral flexion scores in control and experimental groups by paired t - test.

variable	group	N	Mean		SD		Mean diff	t	p - value
			Pre	post	Pre	post			
Right lateral flexion	Control	18	46.61	39.33	3.943	9.141	7.167	33.303	0.004
	experimental	18	46.89	42.17	3.204	2.618	4.667	9.243	0.000

An independent T - test was done to statistically analyze the inter - group variance. There was no significant difference among control group and experimental group on day 1 and at end of 4thWeek as seen in Table4. b.

Table 4 (b): Comparison of intergroup lumbar right lateral flexion scores of pretest and posttest by independent t - test.

	t - test for equality of means		
		T	P (2 - tailed)
Right lateral flexion - pre	Equal variances assumed	0.093	0.927
Right lateral flexion - post	Equal variances assumed	- 1.066	0.294

Hence there is significant improvement in right lateral flexion range of motion in control and experimental group from day 1 to end of 4th week but no significant improvement in intergroup analysis.

Lumbar range of motion (ROM) - Left lateral flexion: Left lateral flexion range of lumbar spine has improved in two groups evident as shown in Table5. a. A statistical analysis was done to observe intra - group variation using paired T - test.

Table 5 (a): Comparison of pretest and posttest lumbar left lateral flexion scores in control and experimental groups by paired t - test

variable	group	N	Mean		SD		Mean diff	t	p - value
			Pre	post	pre	post			
Left lateral flexion	Control	18	46.17	39.33	4.004	9.146	6.833	3.059	0.007
	experimental	18	46.89	42.17	3.833	3.698	4.722	6.893	0.000

An independent T - test was done to statistically analyze the inter - group variance. There was no significant difference among control group and experimental group on day 1 and at end of 4thWeek as seen in Table5. b.

Hence there is significant improvement in left lateral flexion range of motion in control and experimental group from day 1 to end of 4th week but no significant improvement in intergroup analysis.

Table 5 (b): Comparison of intergroup lumbar left lateral flexion scores of pretest and posttest by independent t - test

	t - test for equality of means		
		T	P (2 - tailed)
Left lateral flexion – pre	Equal variances assumed	- 0.533	0.584
Left lateral flexion – post	Equal variances assumed	- 1.218	0.231

Lumbar stability: Ability to maintain stability of lumbar spine has improved in two groups evident as shown in Table6. a. A statistical analysis was done to observe intra - group variation using paired T - test.

Table 6 (a): Comparison of pretest and posttest lumbar stability scores in control and experimental groups by paired t - test

variable	group	N	Mean		SD		Mean diff	t	p - value
			pre	post	pre	post			
Lumbar stability	Control	18	36.5	38.89	3.502	1.367	- 2.389	- 3.749	0.002
	experimental	18	36.22	38.89	2.579	1.079	- 1.667	- 4.331	0.000

An independent T - test was done to statistically analyze the inter - group variance. There was no significant difference among control group and experimental group on day 1 and at end of 4thWeek as seen in Table6. b.

Hence there is significant improvement in lumbar stability in control and experimental group from day 1 to end of 4th week but no significant improvement in intergroup analysis.

Table 6 (b): Comparison of intergroup lumbar stability scores of pretest and posttest by independent t - test

	t - test for equality of means		
		T	P (2 - tailed)
Lumbar stability - pre	Equal variances assumed	0.271	0.788
Lumbar stability - post	Equal variances assumed	0	1

Modified Oswestry Disability Index (mODI): The findings of the present investigation indicate that functional diability has decreased in two groups evident as shown in Table7. a. A statistical analysis was done to observe intra - group variation using paired T - test.

Table 7 (a): Comparison of pretest and posttest mODI scores in control and experimental groups by paired t - test

variable	group	N	Mean		SD		Mean diff	t	p - value
			pre	post	pre	post			
mODI	Control	18	31.22	6.22	19.234	6.958	25	7.279	0.000
	experimental	18	28.78	6	10.828	5.615	22.77	10.496	0.000

An independent T - test was done to statistically analyze the inter - group variance. There was no significant difference among control group and experimental group on day 1 and at end of 4thWeek as seen in Table7. b.

Table 7 (b): Comparison of intergroup mODI scores of pretest and posttest by independent t - test

	t - test for equality of means		
		T	P (2 - tailed)
mODI - pre	Equal variances assumed	0.47	0.641
mODI - post	Equal variances assumed	0.105	0.917

Hence there is significant improvement in functional disability in control and experimental group from day 1 to end of 4th week but no significant improvement in intergroup analysis.

Diaphragm thickening fraction (DTF) - Right: Diaphragm thickening fraction of right dome of diaphragm has increased significantly in experimental group but not in control group evident as shown in Table8. a. A statistical analysis was done to observe intra - group variation using paired T - test.

Table 8 (a): Comparison of pretest and posttest DTF - right scores in control and experimental groups by paired t - test

Variable	group	N	Mean		SD		Mean diff	t	p - value
			Pre	post	pre	post			
DTF - right	Control	18	39.722	51.394	19.645	21.32	- 11.672	- 1.839	0.083
	experimental	18	36.594	51.972	19.57	16.52	- 15.377	- 2.72	0.015

An independent T - test was done to statistically analyze the inter - group variance. There was no significant difference among control group and experimental group on day 1 and at end of 4thWeek as seen in Table8. b.

Table 8 (b): Comparison of intergroup DTF - right scores of pretest and posttest by independent t - test

	t - test for equality of means		
		T	P (2 - tailed)
DTF - right - pre	Equal variances assumed	0.479	0.635
DTF - right - post	Equal variances assumed	- 0.091	0.928

Hence there is significant improvement in pain reduction in experimental group from day 1 to end of 4th week and not in control group, but no significant improvement in intergroup analysis.

Diaphragm thickening fraction (DTF) - Left: Diaphragm thickening fraction of left dome of diaphragm has increased in experimental group than in control group evident as shown in Table9. a. A statistical analysis was done to observe intra - group variation using paired T - test.

Table 9 (a): Comparison of pretest and posttest DTF - left scores in control and experimental groups by paired t - test.

variable	group	N	Mean		SD		Mean diff	t	p - value
			Pre	post	pre	post			
DTF - left	Control	18	45.68	48.92	26.83	21.85	- 3.244	- 0.439	0.666
	experimental	18	38.17	52.42	21.56	21.4	- 14.255	- 1.524	0.143

An independent T - test was done to statistically analyze the inter - group variance. There was no significant difference among control group and experimental group on day 1 and at end of 4thWeek as seen in Table9. b.

Table 9 (a): Comparison of pretest and posttest DTF - left scores in control and experimental groups by paired t - test

	t - test for equality of means		
		T	p (2 - tailed)
DTF - left - pre	Equal variances assumed	0.926	- 0.261
DTF - left - post	Equal variances assumed	- 0.485	0.63

Hence there is no significant improvement in diaphragm thickening fraction - left dome in control and experimental group from day 1 to end of 4th week and no significant improvement in intergroup analysis.

4. Discussion

The results indicated that conventional therapy and diaphragmatic intervention significantly decreased pain, increased the flexibility and stability of spine, improved functional disability and increased diaphragm muscle thickening fraction at the end of four week treatment program, and they were observed by NPRS, lumbar ROM, lumbar stability, Modified Oswestry disability index (mODI), diaphragm thickening fraction (DTF).

Lumbar range of motion has improved significantly in experimental group than in the control group. This proves that diaphragmatic intervention which includes doming of the diaphragm technique and diaphragmatic breathing play an important role in treatment of non - specific low back pain by reducing the tightness in the lower cross. Problem in diaphragm or any of these facial connections will lead to dysfunction, causing alteration in any part of the body covered by this connective tissue sheet (8).

Studies suggest that diaphragm dysfunction and lumbago are interrelated, and that by improving diaphragm function, pain and disability in patients with NS - CLBP may decrease. There are two theories to support this statement. Firstly, according to gate control theory, skin tends to counteract the painful stimulus carried by small - diameter never fibers by applying a stimulus which is conducted by large diameter nerve fibers, thereby inhibiting the pain at spinal level. Diaphragm being a highly innervated muscle, the pressure stimulus applied in doming of diaphragm effectively influences and decreases the input of pain (9).

Diaphragmatic breathing provides with general relaxation.

Evidence from animal experiments suggests that nociceptive inhibitory action of vagal afferents mediated by vagal nerve stimulation activated the descending cervical propriospinal neurons which inhibit the ascending spinothalamic pathways that transmit pain (10). Diaphragm being abundantly innervated by vagus nerve, mechanical stimulation received by the vagal afferents activated this pathway, thus decreasing pain perception.

Breathing pattern Disorders increase levels of anxiety and apprehension, which are sufficient to alter motor control and to influence balance control. Hyperventilation results in respiratory alkalosis, leading to reduced oxygenation of tissues, muscle constriction, elevated pain perception, changes in serum calcium and magnesium levels, and encouragement of the development of myofascial trigger points – all or any of which are capable of modifying normal motor control of skeletal musculature. Correction of faulty breathing pattern by doming of diaphragm and diaphragmatic breathing reverses these biochemical and biomechanical changes and, thereby reduces the perception of pain and development of myofascial trigger points also helps in improving functional diabilities (11).

Biomechanical changes in a muscle which leads to muscle shortening will also lead to compensation in the adjacent and distant muscles. This relationship supports the hypothesis that doming of diaphragm followed by diaphragmatic breathing improves lumbar mobility thereby increasing the spinal flexibility (12).

Intra - abdominal pressure is responsible for maintenance of trunk stability and posture. Studies have showed that all the muscles of the core work in synergy to maintain intra - abdominal pressure. Apart from respiration, diaphragm also plays an important role in posture control and trunk stability. In subjects with low back pain, because of impaired breathing pattern there is dysfunction of diaphragm muscle leading to its inability to contribute for increasing the intra - abdominal pressure (13) (14) (15). Because of increased demands of one of its functions, i. e., breathing and postural control, diaphragm inevitably abolishes the other function. Unlike healthy individuals where diaphragm compensates for increased respiratory demand, this compensation seems less effective in persons with breathing dysfunction which leads to greater diaphragm fatigability. This may be a potential underlying mechanism for non - specific low back pain (16).

Doming of the diaphragm with diaphragmatic breathing decreases the hypertonicity of the muscle by stretching the shortened fibers and thereby increasing the mobility of the muscle. This flexibility of the muscle allows for better functioning of the diaphragm and makes it capable of contributing to stability and posture control by increasing intra - abdominal pressure by contracting either during respiration or postural control (17) (18) (19). A study proves the effect of diaphragm training on lumbar stabilizer muscles where lumbar multifidus has an important role in the segmental control mainly during lifting and rotational movements. Transversus abdominis muscle attaches to the thoracolumbar fascia; therefore, it is capable of increasing the stiffness of the lumbar spine indirectly. The pelvic floor muscles and diaphragm are in synergism with transversus abdominis, and they are responsible for maintaining and increasing intra - abdominal pressure during several postural tasks (20). A study of the diaphragmatic thickness lung volume relationship in vivo concluded that diaphragmatic thickening fraction (DTF) is directly related to lung volume and may be a useful technique for evaluating diaphragmatic Function (21). There are studies that proved that manual release of diaphragm increased diaphragm mobility but not thickness in healthy volunteers. (22) Our study showed that in subjects with non - specific low back pain, there was a significant increase in diaphragm thickening fraction in both the groups which is affected directly by the length - tension relationship (23) (24). A study carried out In young individuals showed that diaphragm thickness is related to diaphragm muscle strength, but diaphragm thickness is not related to endurance. It also showed that diaphragm strength is not related to endurance (25).

5. Conclusion

Both control group and experimental group were effective in improving pain, lumbar ROM, lumbar stability, DTF and functional disability clinically. Statistical significance is seen in NPRS, lumbar ROM, lumbar stability, DTF right and SEBQ and statistical insignificance is seen in DTF left intragroup analysis. During intergroup analysis, no significant difference was found between the control and experimental group. Further studies need to be conducted in this direction to examine the long term effects of pain relief, improvement in disability and muscle strength.

Conflicts of interest

Authors declare no conflicts of interest.

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