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IMMEDIATE EFFECT OF HOLD-RELAX STRETCHING VERSUS STATIC STRETCHING OF ILIOPSOAS MUSCLE ON TRANSVERSUS ABDOMINIS MUSCLE ACTIVATION IN CHRONIC MECHANICAL LOW BACK PAIN WITH LUMBAR HYPERLORDOSIS

-A comparative study

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Abstract: Main goal of the treatment is to reduce the pain, lumbar hyperlordosis and enhance function by improvement in the TrA activation, lumbar stability and iliopsoas muscle length by stretching of the iliopsoas muscle in chronic mechanical low back pain patients with hyperlordosis.

Method: Total 80 patients with chronic mechanical low back pain with lumbar hyperlordosis were selected from OPD setups/hospitals. Each patient was clinically assessed by the first author based on the inclusion and exclusion criteria. Following pre-test the patient were assigned to receive the intervention either Hold-relax stretching group or Static stretching group. All patients were assessed pre and post-test by the first author. The immediate effect of these interventions were measured and compared using outcome measures like Visual analogue scale, Transversus abdominis activation using pressure biofeedback unit, Modified isometric stability test for Lumbar stability, Lumbar lordosis angle using flexiruler and iliopsoas muscle length by measuring passive hip extension in modified Thomas test position. Statistical analysis was done using Mixed way ANOVA test.

Result: On comparison of pre and post treatment values, both hold-relax stretching and static stretching of iliopsoas muscle showed significant effect by reducing pain , lumbar lordosis angle and improving transversus abdominis muscle capacity , lumbar stability and iliopsoas muscle length. ($p<0.0001$) On comparison between hold-relax stretching group and static stretching group, extremely significant difference found for VAS ($p=0.001$), Transversus abdominis activation ($p=0.047$), lumbar stability ($p=0.028$) and lumbar lordosis angle ($p=0.025$). Whereas, significant difference was found for left iliopsoas muscle length (0.008) when compared between both groups but the right iliopsoas muscle length ($p=0.069$) did not show any significant difference.

Conclusion:_The study concludes that both hold-relax and static stretching of iliopsoas muscle was effective in improving the transversus abdominis activation in chronic mechanical low back pain with hyperlordosis. Further, Iliopsoas stretching improved pain, lumbar stability, lumbar lordosis angle and unilateral iliopsoas muscle length in these patients.

Index Terms –Hold- relax stretching, Static stretching, lumbar hyperlordosis, iliopsoas.

I. INTRODUCTION

Low back pain is one of the serious health problem worldwide affecting 80–85% of people over their lifetime and is a highly prevalent condition associated with work absenteeism, disability and large health care costs [1,2]. It can impact an individual in many ways ranging from pain and activity limitations to participation restriction, carer burden and financial burden[2]. Epidemiological evidence suggests that the incidence of low back pain is 23.09% in India and lifetime prevalence of about 60-80%. Low back pain is found to be equally affecting both male and females.[3] Low back pain is a common musculoskeletal impairment that affects the population with vital implications on clinical, social, economic and public health.[4]

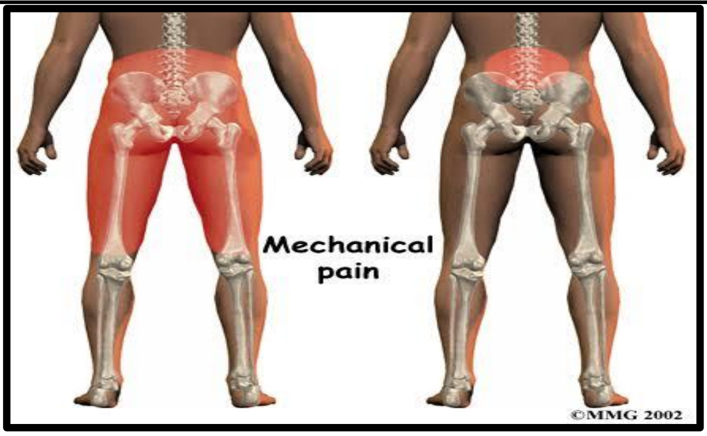

Figure 1: distribution of mechanical low back pain

Low back pain has become a problem with increasing healthcare costs [5] and only 20% of population seeks medical attention for low back pain. Hence, the economic burden of health care costs on society is huge and can be divided as direct costs of health care utilisation like hospitalisation, medication, tests and therapies and indirect costs of lost productivity due to work absenteeism and early retirement.[6] Most of the acute low back pain disorders resolve within 4 weeks though recurrence may occur [7] and a small number of disorders becomes chronic (10-40%) .[8] Chronic low back pain has been found to restrict the physical and social life by considerably affecting their lifestyle. Various socio-economic risk factors like job dissatisfaction, physically strenuous work, low education and Worker's Compensation insurance were found to be associated with chronic low back pain onset and its persistence and were further responsible as the cause of disability.[9,10] Factors like smoking, obesity, psychological Introduction distress and depressive mood were reported to add up to the risk of persistent symptoms and disability.[11]

An episode of low back pain greater than 12 weeks was classified as chronic low back pain [12] and is the most frequent cause of activity limitation in people below age 45 [13]. Chronic low back pain is found to be associated with physical factors such as abnormal posture, lumbopelvic alignment and alterations in the muscle length and mobility of the lumbar spine [14]. Mechanical low back pain varies with physical activity (e.g. prolonged sitting, bending forward) with time.[15] Mechanical back pain can be caused due to can be due to involvement of any structure within the spine including the vertebral bodies, intervertebral discs, zygapophysial joints, sacroiliac joints, spinal ligaments, paraspinal muscles, dura, spinal cord, and nerves [16]. Static muscle load and flexion of the lumbar spine are considered as risk factors for causing low back pain thus, prolonged sitting or sitting in an abnormal posture for long time aggravates low back pain [17].

Figure 2: activities that cause mechanical low back pain

Low back pain was classified by Waddell that divided it into three categories: 1) pain caused by specific spinal pathology, e.g. tumor, infection or trauma, (2) nerve root or radicular pain and (3) nonspecific low back pain that comprises of large heterogeneous group of patients.[18] The initiation and exacerbation of chronic low back pain is found to be associated with mechanical factors such as sustained low load posture and movement, exposure to whole body vibration and repeated spinal loading. These factors may have a deleterious effect on the musculoskeletal system.[19] Low back pain is usually either nonspecific or mechanical. Mechanical low back pain emerges intrinsically from the spine, intervertebra discs or from surrounding soft tissues.[20]

Iliopsoas muscle has direct attachments to the spine, pelvis and femur and hence, is influenced by movements at spine or hip joint. It is a postural muscle and has been observed to undergo shortening. Its shortening can tend to exaggerate the lumbar lordosis and anterior pelvic tilt [21]. Muscle is the potential cause of low back pain. [22] Transversus abdominis (TrA) muscle and mulitifidus are activated faster than other deep trunk muscles while adjusting balance or when body moves [23]. Chronic low back pain is directly associated with dysfunction of transversus abdominis muscle along with reduced lumbar flexibility as this muscle is directly attached to thoracolumbar fascia. Its weakness can decrease shear strain to the thoracolumbar fascia. Normally thoracolumbar fascia increases intra-abdominal pressure (IAP) causing unloading and stabilization of lumbar spine. But in case of weakness of the muscle decreases IAP leading to reduced lumbar stability and increased loading on the spine [24]. According to the study done by Mulhearn et. al where they compared the TrA muscle activation in individuals with lumbar hyperlordosis, sway back and normal posture, the relationship of TrA muscle inhibition was found most significant with lumbar hyperlordosis than other postures [25]. Hence, hyperlordosis can inhibit the activation of the transversus abdominis muscle in patients with chronic low back pain. In patients with chronic low back pain, the deep trunk muscles tend to undergo atrophy along with weakened proprioceptive senses leading to spinal instability which further leads to recurrent low back pain. [26]

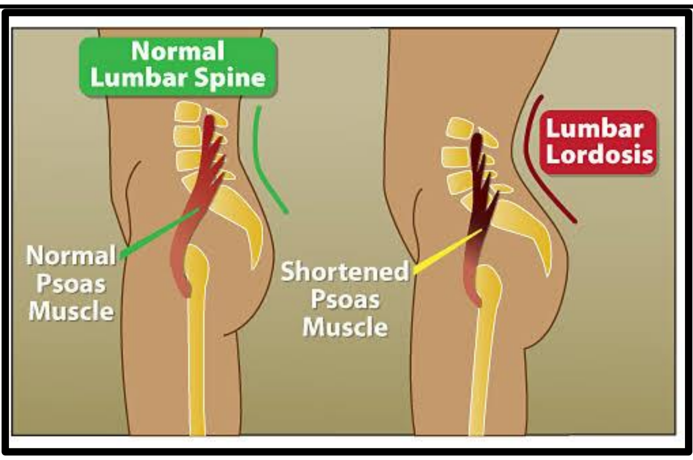

Figure 3: effect of iliopsoas muscle shortening on lumbar lordosis

Another classification of chronic low back pain based on the mechanism of the disorder divides it into sub-groups as: First group of disorders in which the underlying pathological processes drives the pain and the motor responses of the patient in the disorder are adaptive. Second group of disorders in which psychological and/or social factors are the primary mechanism underlying the disorder that centrally drives pain and the patient's coping and motor control strategies are mal-adaptive in nature. There is a large group of chronic low back pain disorders where the patients have either movement impairments that are characterized by pain avoidance behaviour or control impairments that are characterized by pain provocation behaviour. These disorders are induced mechanically that further leads to mechanism for ongoing pain. These patients may have either excess or reduced spinal stability.[27,28,29]

Different forms of proprioceptive neuromuscular facilitation (PNF) are effective in improving the joint ROM. Hold- relax PNF is one of the PNF technique used widely and it consists of pacing joint in maximum available ROM and performing a submaximal isometric contraction against resistance for 5-10 seconds and followed by complete relaxation taking the joint to new range of motion. The submaximal isometric contraction causes the relaxation of the muscle by activation of the golgi tendon organ by autogenic inhibition [30].

Static stretching is a commonly used stretching method in which soft tissues are elongated just past the point of tissue resistance and held in lengthened position with a sustained stretch force over a period of time usually ranging from 5 second to 5 minutes. Although in review of the literature of studies done on calf muscle stretching show 30 seconds hold per repetition as median duration of hold. [30]

In a previous study done to compare effectiveness of static stretch and PNF stretch on hamstrings muscle they found PNF to be more effective than static stretch in improving ROM in a single session [31]. Another study done by Hashim Ahmed et. al aimed to compare the effects of modified hold-relax stretching and static stretching in improving hamstring muscle flexibility in which they found both modified hold-relax stretching and static stretching effective in improving hamstring flexibility [32]. Previosuly, no study has been done to compare the effect of hold-relax and static stretching on iliopsoas muscle and its effect on pain, TrA activation, lumbar stability, lumbar lordosis angle and iliopsoas muscle length.

II. METHODOLOGY:

Study design: Comparative study
Study setting: Hospitals/ OPD in Nashik city
Duration of study: 1 year
Sample size: 84
Sampling technique: Covinience sampling technique

INCLUSION CRITERIA-

1. Age group of 20-45 years of age [13]
2. Both sexes
3. Chronic mechanical low back pain for >3 months
4. VAS > 4/10 and <7.5/10 [34]
5. BMI range between 18.5- 25 Kg/m^2 [33]
6. Lumbar lordosis angle > mean of normal plus standard deviation from previous study. [41]
7. Iliopsoas muscle tightness of atleast one side (positive by Modified Thomas test). [51]

EXCLUSION CRITERIA-

1. Red flags for serious spinal conditions (eg. tumors, infection, osteoporosis, etc)
2. Past history of abdominal, back or hip surgery.
3. Fracture of the spine and hip.
4. Neurological disease (eg. cauda equine syndrome, nerve root lesion, etc)
5. Pain and severe joint stiffness of hip and knee.
6. Cardiovascular and respiratory system problems.

Appropriate subject withdrawal criteria:
Participants who were not willing to participate or not able to perform tests included in the study due to pain were given complete freedom to withdraw from the study as mentioned in consent form.

III. METHOD OF DATA COLLECTION:

Ethical clearance was taken from the Institutional Ethical Committee. 84 patients with chronic mechanical low back pain with lumbar hyperlordosis were selected from OPD setups/hospitals in Nashik city. But due to the patients inability to perform the test due to pain there were 4 droupouts. Each patient was clinically assessed by the first author based on the inclusion and exclusion criteria. Patients were included in the study with history of chronic mechanical low back pain for more than 3 months, which usually worsened by activity (particularly bending, extending, twisting and lifting) and improved partially by rest, restricted ROM of the spine, paraspinal muscle spasm, muscular trigger points, tenderness and aggravation of symptoms on flexion or extension and straight leg raising tests.(52) Lumbar lordosis angle was measured with the help of flexiruler to check for lumbar hyperlordosis (41,42). Then the patient was bilaterally assessed for shortened hip flexors by the modified Thomas test .If the leg being tested was short of full extension at the hip then the patient was considered of having shortened hip flexor (51) and was included in the study. Similarly, the other leg was checked for the same. Each patient was given a written consent form and was explained the need of the study.

Following pre-test randomization was done by simple random sampling technique by chit method by the first author and then patient was assigned to either Hold-relax stretching group or Static stretching group. All participants in the study were blinded to group allocation while the first author delivering intervention was not blinded to group allocation. All patients were assessed pre and post intervention by the first author for the following outcome measures:

1) Visual analogue scale:

Pre intervention and post intervention pain intensity was marked on the 10-cm line with starting point marked as no pain and last point as worst pain. It was measured from the start of line to the point marked. VAS is found to be a reliable method to assess pain intensity with fair to good test-retest reliability (0.66-0.93).(35)

Both TrA activation capacity and lumbar stability level was measured by Pressure bio-feedback unit.

2) Transverse abdominal muscle capacity:

Pre and post TrA activation capacity was assessed by the prone test with the Pressure bio-feedback unit (PBU). Before measurement, all participants were instructed and the abdominal hollowing action was practiced in hook lying and prone positions, once for each position. Then the patients received the same instructions for abdominal hollowing action in prone and the PBU with pressure of 70mm Hg placed below the abdomen and the pressure changes were reported as negative pressure reduction (mmHg). The pressure patient was able to hold for 10 seconds was recorded. This method of assessing the transversus muscle activation is found to be a reliable method with ICC of 0.47 with 95% CI for inter-observer reliability, and an ICC of 0.81 with 95% CI for test-retest reliability. (38)

Figure 4: transversus abdominis muscle activation using pressure biofeedback unit

3) The lumbar stability level:

It was assessed by the modified isometric stability test (MIST). The patient was asked to lie in hook lying position and the PBU was placed below lumbar spine (between the back and the table), with pressure of 40mm Hg. The patient had to perform exercise without moving the pressure gauge dial and the examiner looked for the changes in the pressure on the pressure dial. The MIST comprises of a set of six progressive exercise tests: level 1: abdominal hollowing, level 2: unilateral hip abduction, level 3: unilateral knee extension, level 4: unilateral knee raise, level 5: bilateral knee raise, level 6: bilateral knee raise together. If the patient is able to maintain the pressure at 50mm Hg for three breathing cycles then the patient has passed level 1 and was instructed to perform next level while maintaining the abdominal pressure at each level. The highest performance level was recorded. This method was found to be reliable method to assess the lumbar stability with value of weighted k coefficient of 0.61 as intratester and 0.62 as intertester reliability. (40)

Figure 5: modified isometric stability test using pressure biofeedback unit

4) The lumbar lordosis angle:
Pre and post intervention lumbar lordosis angle was measured by a flexible ruler. S2 spinous process was palpated and marked between both PSIS. L1 spinous process was traced by palpating spinous process upwards and marked. The flexiruler was positioned firmly contouring the flexiruler to the skin over spinous process of L1 and S2. Skin markings at L1 and S2 were transferred to flexiruler with pencil. The flexiruler was then placed on piece of paper and the curve representing the shape of back was transferred to the paper. The lordosis angle was calculated by the following formula based on the Hard and Rose method:

$$\theta = 4 \arctan 2 h/l$$

where, l = The length of the line connecting between the point of lumbar level 1 and sacrum level 2.
h = The length of the perpendicular line between the center of l and the curve.

This method of measuring lumbar lodosis angle was determined as a reliable clinical measure with intratester testretest reliability (ICC=0.97, N=89).[42] The lordosis angle obtained was be compared with mean of normal plus standard deviation from previous study.[41]


Figure 6: measuring lumbar lordosis angle using flexiruler

5)The length of the iliopsoas muscle:
Pre and post intervention length of iliopsoas muscle was assessed by the modified Thomas test using a goniometer. The patient had to lie in supine position with knees extending off the edge of the table. One knee is flexed tightly against chest, maintaining the lumbar spine flat on table and the other leg hanging down on table. Then the hip ROM of the leg on the table was measured with goniometer with the fulcrum at hip joint and the stable arm of goniometer over lateral midline of the trunk and moving arm over lateral midline of the thigh. The passive range of motion (ROM) of hip extension represented the length of the iliopsoas muscle. This method was found reliable method to measure with the value of ICC= 0.92.[43]


Figure 7: iliopsoas muscle length using goniometer

Intervention included two groups as follows:

Group A: Hold-relax stretching group- The participants received hold-relax stretching for iliopsoas muscle in the modified Thomas test position. The target lower extremity (thigh) was moved towards the floor until a mild stretch sensation was felt by the participant. Then the participant was asked to do a submaximum voluntary isometric contraction (approx. 25 % MVIC) of the iliopsoas muscle for 10 seconds followed by period of 10 seconds of relaxation. The participants leg was then slowly taken to the new range until a mild stretch was felt and held for 20 seconds in the same position followed by 1 minute rest. Frequency: 5 repetitions.[17]

Figure 8: hold-relax stretching of iliopsoas muscle

Group B: Static stretching group- The participants received static stretching of iliopsoas muscle in the modified Thomas test position. The target lower extremity (thigh) was moved towards the floor until a stretch sensation was felt by the participant with a hold of 30 seconds followed by a rest period of 15 seconds. Frequency: 5 repetitions.[30]

Figure 9: static stretching of iliopsoas muscle

Statistical analysis:

The entire data of the study was entered in MS Excel sheet before it was statistically analyzed in SPSS software version 16.0 for Windows. The data of quantitative characteristics was presented as Mean ± Standard Deviation (SD) across two study groups.The statistical significance of difference of qualitative characteristics between two study groups (inter-group comparisons) was tested using Independent t test to rule out the baseline differences and maintain homogeneity between the two study groups. The statistical significance of difference of gender distribution was tested using Z test of two proportions to rule out the baseline differences and maintain homogeneity between the two study groups. A Mixed way ANOVA is used to determine whether any change in VAS, TrA ,MIST, etc (i.e., the dependent variable) is the result of the interaction between the type of group (i.e., SS group and HR group that is, the "conditions", which is the "between-subjects" factor) and "time" (i.e., the within-subjects factor, consisting of two time points). The statistical significance of difference of pre-treatment and post-treatment quantitative characteristics in each study group (intra-group comparisons) was tested using Mixed way ANOVA test.The statistical significance of difference of mean of quantitative

characteristics between two study groups (inter-group comparisons) was tested using Mixed way ANOVA test. The p-values less than 0.05 are considered to be statistically significant. All the hypothesis was formulated using two tailed alternatives against each null hypothesis (hypothesis of no difference).

IV. RESULT

Each group consisted of 40 patients with 22 males and 18 females in the hold relax stretching group and 20 males and 20 females in the static stretching group. Independent t test was used to compare the distribution of age and BMI in both the groups. There was a significant difference found in the age distribution between both the groups (p=0.015). While, no significant difference was found in the BMI distribution (p=0.935). Gender distribution between both the groups was compared using z test of two proportions which showed no significant difference (male-p=0.65, females-p=0.65). For the comparison within both groups and between groups Mixed way ANOVA was used. The results in the present study shows that both hold-relax stretching and static stretching of iliopsoas muscle showed significant effect by reducing pain , lumbar lordosis angle and improving transversus abdominis muscle activation, lumbar stability and iliopsoas muscle length. On comparison of hold relax stretching group for pre-test and post-test values of VAS (p<0.0001), Transversus abdominis activation (p<0.0001), MIST level (p<0.0001), lumbar lordosis angle (p<0.0001) and iliopsoas muscle length (p<0.0001) significant difference was found. Similarly, on comparison of static stretching group for pre-test and post-test values of VAS (p<0.0001), Transversus abdominis activation (p<0.0001), MIST level (p<0.0001), lumbar lordosis angle (p<0.0001) and iliopsoas muscle length (p<0.0001) extremely significant difference was found (p<0.0001) . On comparison between hold-relax stretching group and static stretching group, there was significant difference found for VAS (p=0.001), Transversus abdominis activation (p=0.047), lumbar stability (p=0.028) and for lumbar lordosis angle (p=0.025) between both groups. Whereas, significant difference was found for left iliopsoas muscle length (0.008) when compared between both groups but the right iliopsoas muscle length (p=0.069) did not show any significant difference between both the groups.

Table No.1 intra-group comparison of vas for group a & group b

Source		**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**p-value**
Time	Sphericity Assumed	17181.025	1	17181.025	311.303	0.000
time * Group	Sphericity Assumed	1416.100	1	1416.100	25.658	0.000
Error(time)	Sphericity Assumed	4304.875	78	55.191		

Table No.2 pairwise comparison of mean difference of means of vas of 2 time points (pre and post)

Group A	**Group B**	**Mean Difference**	**Std. Error**	**p-value**
HR Group	SS group	-6.800*	2.013	0.001

Table No.3 intra-group comparison of tra activation for group a & group b

Source		**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**p-value**
Time	Sphericity Assumed	21.756	1	21.756	139.240	0.000
time *Group	Sphericity Assumed	4.556	1	4.556	29.160	0.000
Error(time)	Sphericity Assumed	12.188	78	0.156		

Table No.4 pairwise comparison of mean difference of means of tra activation of 2 time points (pre and post)

Group A	**Group B**	**Mean Difference**	**Std. Error**	**p-value**
HR Group	SS group	0.288*	0.143	0.047

Graph No.1 the distribution of pre-treatment and post-treatment of tra activation between two study groups

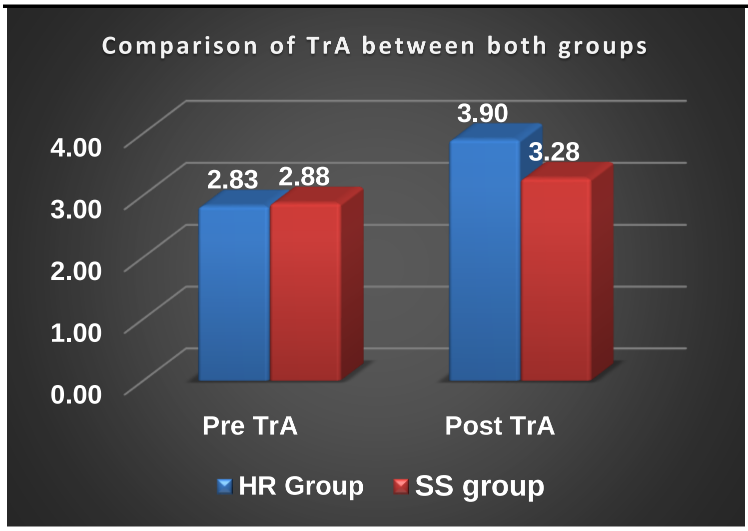

Table No.5 intra-group comparison of mist for group a & group b

Source		Type III Sum of Squares	df	Mean Square	F	p-value
Time	Sphericity Assumed	42.025	1	42.025	173.666	0.000
time * VAR00001	Sphericity Assumed	12.100	1	12.100	50.003	0.000
Error(time)	Sphericity Assumed	18.875	78	0.242		

Table No.6 pairwise comparison of mean difference of means of mist of 2 time points (pre and post)

Group A	Group B	Mean Difference	Std. Error	p-value
HR Group	SS group	0.525*	0.234	0.028

Table No.7 intra-group comparison of lumbar lordosis angle for group a & group b

Source		Type III Sum of Squares	df	Mean Square	F	p-value
Time	Sphericity Assumed	490.210	1	490.210	66.510	.000
time * VAR00001	Sphericity Assumed	23.608	1	23.608	3.203	.077
Error(time)	Sphericity Assumed	574.895	78	7.370		

Table No.8 pairwise comparison of mean difference of means of lumbar lordosis angle of 2 time points (pre and post)

Group A	Group B	Mean Difference	Std. Error	p-value
HR Group	SS group	-2.129*	0.934	0.025

Graph No.2 the distribution of pre-treatment and post-treatment of lumbar lordosis angle between two study groups

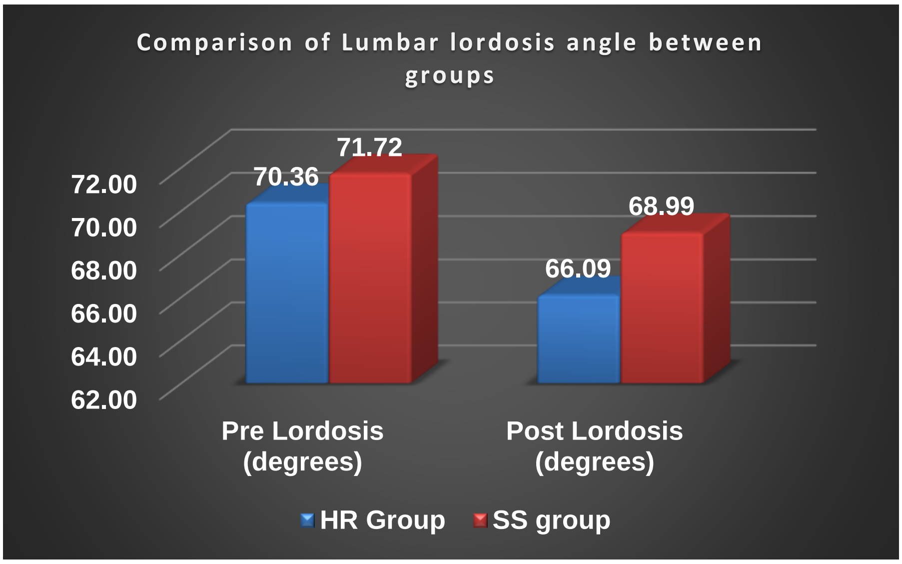

Table No.9 intra-group comparison of right iliopsoas muscle length for group a & group b

Source		Type III Sum of Squares	df	Mean Square	F	p-value
Time	**Sphericity Assumed**	**1587.600**	**1**	**1587.600**	**800.083**	**0.000**
time * VAR00001	**Sphericity Assumed**	**5.625**	**1**	**5.625**	**2.835**	**0.096**
Error(time)	**Sphericity Assumed**	**154.775**	**78**	**1.984**		

Table No.10 pairwise comparison of mean difference of means of right iliopsoas muscle length of 2 time points (pre and post)

Group A	Group B	Mean Difference	Std. Error	p-value
HR Group	**SS group**	**-0.675**	**0.366**	**0.069**

Table No.11 intra-group comparison of left iliopsoas muscle length for group a & group b

Source		Type III Sum of Squares	df	Mean Square	F	p-value
Time	**Sphericity Assumed**	**1703.025**	**1**	**1703.025**	**783.809**	**0.001**
time * VAR00001	**Sphericity Assumed**	**2.500**	**1**	**2.500**	**1.151**	**0.287**
Error(time)	**Sphericity Assumed**	**169.475**	**78**	**2.173**		

Table No.12 pairwise comparison of mean difference of means of left iliopsoas muscle length of 2 time points (pre and post)

Group A	Group B	Mean Difference	Std. Error	p-value
HR Group	SS group	-0.925*	0.338	0.008

V. DISCUSSION

Low back pain is one of the most common musculoskeletal condition in adults with a prevalence of up to 84%.[53] Chronic low back pain is a chronic syndrome that affects the lower back for a period of more than 12 weeks. [54] Mechanical pain means the pain that is caused due to either anatomic or functional abnormality rather than any disease, malignant neoplasm or manifestation of visceral disease. It has mechanical origin and occurs when there is overstretching of the surrounding soft tissues of the joint when the joined is placed in such position.[55] It is an acute form of pain that is characterized by aggravation of symptoms by movement, worsened by coughing and is relieved with rest.[56] It has sudden onset and it may be associated with occupations that requires heavy weight lifting, bending, heavy physical work, static working posture, twisting forces, pushing and pulling activities. [57,58] Structures such as intervertebral discs and joints lesion including degenerative disc lesion, synovitis or strain of the sensory nerves are responsible for mechanical back pain. [59] Clinical findings seen in mechanical low back pain are restricted ROM of the spine, paraspinal muscle spasm, tenderness, trigger points and exacerbation of symptoms on flexion or extension movement of spine and on straight leg raise test.[60] Various treatment interventions in physiotherapy are used to treat chronic mechanical low back pain.

Variable 1:Visual Analogue Scale (VAS)

The results found in this study suggests that Hold-relax stretching and static stretching of iliopsoas muscle is effective in reducing the pain in patients with chronic mechanical low back pain with hyperlordosis. On comaprison of vas scores between the 2 groups the result showed that the difference of pre and post treatment vas did not differ significantly betweenthe two groups, thus reduction in the pain was equal in both the groups. ($p<0.001$) The result found in our study is in accordance with the study done by suthichan et.al in which they found hold-relax stretching of iliopsoas muscle to be effective in reducing pain in patients with chronic mechanical low back pain with hyperlordosis.[47] another study done by meena et. Al in which they found that hold-relax stretching of hamstring muscle to be more effective in reducing pain than static stretching in patient with knee osteoarthritis.[62] hold-relax stretching improves the motor activity of the muscle that boosts its vascular function causing vasodilatation due to release of vasoactive substances. This helps in the washout of pain producing substance p and thereby reducing the pain. [30] also, in pnf the muscles are contracted along with stretching which decreases nociception.[63] in another study done by ali et. Al similar results were found, hold-relax stretching was more effective than static stretching of hamstring muscle in reducing pain in patients with hamstring tightness. [64] no study was done previously on static stretching of iliopsoas muscle in patients chronic mechanical low back pain. The reduction in pain after static stretching of iliopsoas muscle can be explained by the pain-spasm-pain model. Due to shortened iliopsoas muscle causing increased lumbar lordosis may further lead to paraspinal muscle spasm. This guarding may impair circulation which may cause increase in the pain-spasm-pain model.[65,66] as the cause of pain is corrected by stretching of iliopsoas muscle, pain reduced in these patients. Also, static stretching contributes to the neuromuscular relaxation (inhibition) of the stretched muscle by the activation of golgi tendon organ. This reduces the tension in the muscle causing relaxation of the muscle. [30] in a previous study done, in which they found effect of stretching-based rehabilitation on pain, flexibility and muscle strength in dancers with hamstring injury. They found static stretching was effective in reducing the pain. [67]

Variable 2: Transversus abdominis (TrA) activation

This results found in our study suggests that Hold-relax stretching and static stretching of iliopsoas muscle is effective in improving the TrA capacity in patients with chronic mechanical low back pain with hyperlordosis. On comaprison of TrA activation between the 2 groups result showed that the difference of pre and post treatment TrA activation did not differ significantly between the two groups, thus reduction in the pain was equal in both the groups. ($p=0.047$) Both Hold-relax stretching and static stretching of iliopsoas muscle showed increase in the transversus abdominis activation in both the groups. In a previous study done by Suthichan et.al they found Hold-relax stretching of iliopsoas muscle to be more effective in improving TrA activation in patients with chronic non-specific low back pain with hyperlordosis.[47]This study supports our results. Though no study on the static stretching of iliopsoas muscle and its effect on TrA activation has been conducted earlier. In patients with chronic low back pain with hyperlordosis, abnormal loading on the spine occurs. This may cause inhibition of the core muscles which includes transversus abdominis muscle.[68] Also, according to Janda tightened iliopsoas is associated with weakened core muscles.[69] In the present study, Hold-relax stretching of iliopsoas muscle showed increase in the transversus abdominis muscle activation by lengthening the iliopsoas muscle, reducing the hyperlordosis and abnormal loading on the spine. In a study done by Franca et. al they found that stretching program along with segemental stabilization exercises showed improved TrA activation in patients with chronic low back pain. [70]

Variable 3: Modified lumbar stability level (MIST)

The results found in this study suggests that Hold-relax stretching and static stretching of iliopsoas muscle is effective in improving the lumbar stability level in patients with chronic mechanical low back pain with hyperlordosis. On Comparison of MIST between the 2 groups result showed that the difference of pre and post treatment MIST level did not differ significantly between the two groups, thus reduction in the pain was equal in both the groups. (p=0.028) No study has been done prior that determined the effect of static stretching of iliopsoas and its effect on lumbar stability. Though a study has been done in patients with chronic non-specific low back pain with hyperlordosis to determine the immediate effect of Hold-relax stretching of iliopsoas on lumbar stability. This study showed no significant improvement in the lumbar stability level. (47) The results found in our study supports the study done by Franca et. al in which they studied the effect of segmental stabilization exercises compared between stretching pograms of the back and hamstring muscle in chronic low back pain patients for 6 weeks.They found increase in the lumbar stability after 6 weeks.(70) Iliopsoas muscle plays an important role in maintaining the static and dynamic stability of the lumbar spine. The stabilization in the lumbar spine is provided to a major extent by the vertebral portions of the iliopsoas muscle.In a study done by Bruggi et. al they monitored the degree to which asymmetric contractions of the iliopsoas muscle improve the lumbar curve. In this study they found that the corrective exercises that included submaximal isometric contaction of the iliopsoas muscle followed by gradual release showed significant changes in the lumbar curve.(71,72) This supports the result found in our study.

Variable 4: Lumbar lordosis angle

This study suggests that Hold-relax stretching and static stretching of iliopsoas muscle is effective in reducing the lumbar lordosis angle in patients with chronic mechanical low back pain with hyperlordosis. On Comparison of lumbar lordosis angle between the 2 groups result showed that the difference of pre and post treatment lumbar lordosis angle did not differ significantly between the two groups, thus reduction in the pain was equal in both the groups. (p=0.025) Iliopsoas is a phasic muscle and can shorten and become dominant in a motor pattern causing muscle imbalance. Its tightness can lead to increased anterior shear and extension forces on the lower lumbar vertebrae. This is the cause of lumbar lordosis. As with stretching of the cause of lumbar hyperlordosis there might be a decrease in the pull by the muscle on the lumbar spine, Hence, reducing the lumbar lordosis angle. With Hold-relax stretching of iliopsoas muscle the reflexive relaxation of muscle occurs through autogenic inhibition of the muscle further causing its inhibition that helps in lengthening of the muscle by decreased resistance to elongation by the contractile elements of the muscle.(30) In a previous study done to measure the duration of maintained hamstring flexibility after a 1-time, modified hold-relax stretching protocol they found that a sequence of 5 modified hold-relax stretches produced significantly increased hamstring flexibility that lasted 6 minutes after the stretching protocol ended.(73) In our study we also used 5 repititions of hold-relax stretching to be effective in improving the iliopsoas muscle length. In static stretching of the iliopsoas muscle the mechanism behind reduced lordosis angle may be same as that Hold-relax stretching which causes inhibition of the muscle by neuromuscular relaxation.(30) The results in our study may be explained by the possible mechanism that the stretching of iliopsoas muscle by both Hold-relax stretching and static stretching had similar effect of lengthening of the muscle which is supported by another study done by Puentedura et. al they found both the stretching techniques to be equally effective in improving the flexibility of the hamstring muscle. (74) In a previous study done to determine the effect of global postural reducation program on the muscles resting length and extensibility balance within a global postural alignment perspective. This program included stretching of the iliopsoas muscle along with other muscles and found that significant effect was seen on the lumbo-pelvic alignment and lumbar lordosis. (75) This study supports results found in our group.

Variable 5: Length of iliopsoas muscle

This study suggests that -Hold-relax stretching and static stretching of iliopsoas muscle is effective in improving the Iliopsoas muscle length in patients with chronic mechanical low back pain with hyperlordosis. On Comparison of Iliopsoas muscle length between the 2 groups result showed that the difference of pre and post treatment Iliopsoas muscle length did not differ significantly between the two groups for left lower limb, thus increase in the iliopsoas muscle length was equal in both the groups. (p=0.008) While the difference of pre and post treatment Iliopsoas muscle length did differ significantly between the two groups for right lower limb, thus increase in the iliopsoas muscle length was equal in both the groups. (p=0.069) The results in our study showed increase in the length of the iliopsoas muscle by increase in the passive hip extension of unilateral lower limb. The increase in the length of the iliopsoas muscle due to Hold-relax stretching might be explained by the possible mechanism of elongation of viscoelastic muscle-tendon unit and sensorimotor processing. (30) The accepted mechanism for the increase in ROM after Hold-relax stretching is thought to be the body's neurophysiological response to stretch.(76) In a previous study, they determined the the isometric contraction hold time in PNF stretching that best produces gains in hip range of motion and they found that a 3 seconds isometric contraction with 3 repetitions was effective in improving the hip joint flexibility.(77) In our study we used a 10 second sub-maximal isometric contraction which was more than 3 seconds. This might have shown positive results with increase in hip passive extension ROM. While the effect of static stretching can be explained by a prior study done to investigate the effects of three types of stretching on active and passive hip ROM. Passive static stretching was found to be most effective than Hold-relax stretching and active isolated stretching to improve the hip ROM.(78) In a study done by Page, the duration of static stretching required to produce a beneficial effect was found to be 30 seconds which is similar to our study.(79)These studies support our results in this study. Though the increase in right side iliopsoas length was not significant when compared between both the groups. This may be due to the role of dominant leg which may be associated with more tightness. Leg dominance has been studied in femoral slump test where they dominant leg achieved less ROM than non-dominant leg. Limb dominance has been suggested to influence human neuromuscular performance.(80,81) Mostly right leg is found to be dominant than left in the population though further studies should be done in consideration with dominance of the lower limb. In a previous study done by Chiu et. al they found that the immediate effect of static stretching showed significant difference in tendon stiffness in the non-dominant leg but not in the non-dominant leg.(82) This study supports results found in our study.

The aim of the present study was to compare the immediate effect of Hold-relax stretching and static stretching on transversus abdominis activation in the age group 20-45 years with chronc mechanical low back pain with hyperlordosis. From our results both techniques showed improvements on all five outcome measures viz VAS, TrA activation, MIST level and left ilipsoas muscle length while right iliopsoas muscle length showed no improvement. However when the difference of Pre and Post treatment between both the groups for all the five outcome measures were compared, it was found that both treatment groups were equally effective. Thus statistically it was proved that Hold-relax stretching and static stretching of iliopsoas muscle were equally effective in reducing pain, lumbar lordosis angle and improving TrA activation, lumbar stability and iliopsoas muscle length.

CONCLUSION

The results of our study showed that-

- The age group of the subjects did differ significantly between two study groups.
- The gender of the subjects did not differ significantly between the two study groups.
- The BMI of the subjects did not differ significantly between the two study groups.
- Pain, lumbar lordosis reduced and transversus abdominis muscle activation, lumbar stability and iliopsoas muscle length improved significantly in Group A (Hold-relax stretching group).
- Similarly pain , lumbar lordosis reduced and transversus abdominis muscle activation , lumbar stability and iliopsoas muscle length improved significantly in Group B (Static stretching group)
- When compared between groups, both groups were equally effective in reducing pain, lumbar lordosis and improving transversus abdominis muscle activation and lumbar stability patients with chronic mechanical low back pain with lumbar hyperlordosis. Though the right lower limb iliopsoas muscle length showed no effect of iliopsoas muscle stretching, in left lower limb it was effective to improve the iliopsoas muscle length. Thus, it proved to be effective unilaterally.

This study suggests that both types of stretching of the iliopsoas muscle has a beneficial effect in chronic mechanical low back pain with hyperlordosis and the statistically significant changes in the objective measurements indicate that this may be due to increased activation of abdominal muscles especially TrA muscle, improvement in lumbar stabilization, lengthening of the iliopsoas muscle and its effect on the lumbar lordosis that reduced it. The study concluded that both Hold-relax stretching and static stretching of iliopsoas muscle can reduce low back pain, lumbar lordosis and improve the transversus abdominis muscle activation, lumbar stability and length of iliopsoas muscle in chronic mechanical low back pain patients with hyperlordosis.

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