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Effect of Lumbar Stabilisation Exercises using the Stable and Unstable Surface on Pain, Disability and Electromyography (EMG) Activity in Chronic Low Back Pain

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ABSTRACT

Introduction: Non-specific low back pain is one of the common representations of musculoskeletal disorders which can be widely seen all over the world. It is mainly due to the unbalanced and weak muscles of the core, which plays a vital role in maintaining stability and mobility of the spine. Consequently causes recurrence of back pain with activities.

The objective of the study: The study was done to evaluate the effects of lumbar stabilisation exercise using stable and unstable surfaces on pain, disability and electromyographic activity of the Erector spine and transverse abdomen are muscle in chronic low back pain patients (CLBP).

Methods: Twenty-four patients with chronic low back pain were recruited in the study based on inclusion and exclusion criteria. They were randomly allocated into two groups i.e Group A (n=12) lumbar stabilization exercise (LSE) on a stable surface while Group B (n=12) LSE on an unstable surface for 3 sessions per week for 6 weeks in both the groups. The pain was assessed using the Numerous Pain Rating Scale (NPRS), functional disability using Modified Oswestry Disability Index (MODI) Scale and Muscle recruitment pattern using Electromyography (EMG).

Result: Six weeks of interventions showed significant improvement in pain, functional disability and muscle activity of core muscles in both groups ($p < 0.05$). While comparing both groups, there was a significant improvement in pain and muscle activity of the transverse abdominal muscle in Group B patients ($p < 0.05$).

Conclusion: Lumbar stabilization exercises using Swiss balls as unstable surfaces is effective interventional therapy for the alleviation of chronic low back pain and improving the muscle recruitment pattern in patients.

Key Words: Chronic low back pain, Functional Disability, Lumbar Stabilization exercise, Swiss Ball, Erector Spinae muscle, Transverse Abdominis muscle

INTRODUCTION

Mechanical low back pain refers to pain caused by abnormal stress and strain on vertebral column muscles which can be due to poor posture, ill-designed ergonomics or incorrect bending and lifting motions. It is the common representative muscular disorder and consists of spinal instability which further can lead to malfunctioning neuromuscular control.¹Chronic low back pain (CLBP) is normally continuous back pain lasting more than 3 months.²It is widely seen in 70-85% of the population with up to 80% of patients described at least one episode in their life.³According to the world health organization low back pain constituted 37% of all occupational hazards which occupy the first rank among all the diseases.⁴

To provide stability of the lumbar spine, core muscles strengthening and stabilization exercises are important, and Core muscles mainly consist of deep stabilizer muscles are transverse abdominis, multifidus, pelvic floor muscles etc and global muscles are erector spinae, rectus abdominis, latissimus dorsi etc.⁵Core training emphasis strengthening and reconditioning of local and global muscles that work together to stabilize the spine.⁶ The local muscles are slow-twitch fibres while global muscles are torque producing muscles. The inter-segmental local muscle groups provide stabilization and control over supine position with lower force production.⁷

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The major problem is the weakness, lack of motor control and delayed speed of muscles contraction of deep trunk muscles such as multifidus and Transverse Abdominis muscles.⁸ Deep stabilizer muscles in chronic low back pain patients become weak and imbalanced leading to reduced proprioceptive sense which further leads to stability problems in the spine and recurrence of back pain.⁹ Therefore to treat LPB, deep stabilizer muscles exercise is required to balance the muscle control and counteract muscle atrophy. Unstable training equipment, such as Swiss balls, tend to increase the difficulty of performing exercises using complete body-weight and resistance using free weights.¹⁰ Exercises done using Swiss balls employ all body regions and extensively activities can be done in comparison with exercises done on fixed floors. Using balls for performing exercises therefore can enhance the ability of dynamic balance, stability and the flexibility of the spine and improve the sense of balance to prevent injuries.¹¹ So exercises were done on a stable and unstable surface to examine its effects and measures using NPRS scale, MODI scale and surface EMG of core muscles.

Recently a study was done to see the correlation between the effects of trunk stability and LBP. It has been suggested that to stabilize the trunk, correlation of deep and superficial muscles are needed as they are directly attached to the spine and stabilization exercises helps in improving the function of neuromuscular system and hence support as well protect the spine.¹² LSE also helps in maintaining the neutral position of the spine, which is best for unloading of the spine. But no study shows the effectiveness of LSE on stable and unstable surfaces and their impact on global and local core muscle activation patterns in CLBP.¹³

Therefore, the study aimed to determine effective treatment protocol for chronic low back patients by performing LSE on the stable or unstable surface and to find out which exercise is best for reduction of pain, improving the core muscles activities and decreasing the functioning disability in chronic low back pain.

MATERIALS AND METHODS

Design

Pre-test and post-test experimental design.

Participants and Procedure

A total of 24 male and female subjects having chronic non-specific low back pain were recruited based on inclusion and exclusion criteria. Participants were informed about the purpose, procedure and effects of the treatment before the experiment and written consent was taken from them. Ethical clearance was taken from Institutional Ethical Committee Jamia Millia Islamia.

Inclusion Criteria

Non-specific low back pain experienced at least from last 3 months, age 18- 45 years, NPRS score from 3 to 6, MODI score from 20% to 60% (minimal disability to moderate disability), able to attend the hospital for treatment over 6 weeks, Prone instability test positive, Extensor endurance test positive, Aberrant movement pattern present.¹⁰

Exclusion criteria

Patients who have infectious pathology or injury received surgical interventions for their back pain or were awaiting surgery, diagnosis of clinical depression or other specific psychiatric pathology, contradicted to do exercises.¹⁰

All the participants were advised to avoid any other treatment interventions and they were recruited for a 6-week training program.

Measures and Interventions

Demographic data of subjects age (2.1346 ± 4.475), height (1.676 ± 7.471), weight (62.130 ± 0.113) and BMI (21.922 ± 0.610) were taken along with the pre-test outcome measures which include pain level, functional disability and EMG of transverse abdominis and erector spinae. To measure the pain, Numerical Pain Rating Scale (NPRS) was used with an 0-10 integral rating scale. Modified Oswestry Disability Index (MODI) was used to assess the functional disability in CLBP.¹⁴ The coefficient of Cronbach's alpha was 0.92 and test-retest correlation reliability was 0.93.¹⁰

Surface EMG of erector spinae and transverse abdominis were taken by attaching disposable bipolar electrodes with a diameter of 1 cm attached parallel to muscle fibres. Skin preparation was done before the experiment to reduce impedance. Muscle activity of Transverse Abdominis was recorded by attaching surface electrode 2 cm away from the anterior superior iliac spine anteromedially while the activation pattern of the Erector spinae was recorded by attaching electrodes at 3 cm apart from the spinous process at the lateral side.¹² Ground electrode was attached over the superior aspect of the iliac crest of the same side.¹⁵ Every second time of the isometric phase of each exercise the root mean square (RMS) of EMG amplitude was calculated and then mean RMS obtained from three Maximum Voluntary Contraction trials for each muscle was used to provide a basis for EMG amplitudes normalization of data obtained during the experimental exercises (%MVC). The static phase of the experimental exercise was analysed, using means of three trials. The root means square (RMS) for the 3 repetitions of TA and ES muscles were normalised using 100 (%MVC).¹⁶

Treatments

Participants are randomly assigned into two groups by using computer randomization Group A (n=12) and Group B (n=12). In Group A patients performed Lumbar Stabilization

exercises on a stable surface along with hot fomentation for 10 min while Group B received hot packs for 10 min along with lumbar stabilization exercises on an unstable surface i.e Swiss ball. Equilibrium is maintained for 10 sec with a break of 3 seconds between repetitions for 40 min a day. Exercise protocol for both the groups was Back Bridging Exercise, Prone on Elbow, Posterior Pelvic Tilt, Abdominal Crunches and abdominal hollowing. Patients were instructed to maintain the final position for 10 sec then return to the initial position.¹⁰

Before initiation of each exercise program patients were given detailed verbal commands and visual clues or illustrations of exercise to patients emphasizing the starting and ending position. The selection of appropriate Swiss balls was based on demographic data given earlier. Group B was advised that the hip region must be parallel to the floor and the patient knee must maintain an angle of 90° while sitting on the Swiss ball.¹⁷

Duration of treatment: Both groups received treatment for 3 days a week × 6 weeks, 10 times/set, 3 sets.¹⁰

Data analysis

Data were assessed by SPSS version 17.0. Shapiro -Wilk test for the normality of the distribution scores. The demographic characteristic and the baseline criterion measure were compared between the two experimental groups at the study evaluated by an independent t-test. Then a paired t-test was applied to analyze the effect of intervention in two groups for the measures of pain (NPRS), functional disability (MODI) and muscle activation of TA and ES muscles using EMG.

RESULTS

Patients Demographic

To prove the homogeneity between the two groups contrasting baseline criterion measurement was done using an independent t-test. No significant difference seen in baseline value of (p>0.05), Table 1

Table 1: Demographic data and Baseline Criterion Measures

Variables	Group-A Mean(SD)	Group-B Mean(SD)	t-value	p-value
Age	25.75(4.475)	26.58(2.610)	0.557	0.583
Height	1.68(0.113)	1.67(0.090)	0.300	0.767
Weight	61.00(7.471)	63.50(6.023)	0.902	0.377
BMI	21.92(2.610)	22.92(2.875)	0.892	0.382
NPRS	4.58(0.996)	4.75(1.138)	0.382	0.706
MODI	32.50(8.273)	31.33(8.49)	0.341	0.737
EMG-TA	0.165(0.108)	0.102(0.049)	1.849	0.078
EMG-ES	0.901(0.665)	0.691(0.420)	1.099	0.283

Table 2: Comparison of post-test Criterion measures between groups

Variables	Group A Mean(SD)	Group B Mean(SD)	t-value	p-value
NPRS	0.50(0.07)	0.00(0.00)	2.171	0.041*
MODI	6.833(1.992)	6.83(1.585)	0.000	1.000
EMG-TA	0.307(0.141)	0.52(0.167)	3.433	0.002*
EMG-ES	0.901(0.665)	0.69(0.421)	0.925	0.365

Analysis of data within groups

Paired t-test was used to distinguish the comparison between outcome variables at the baseline and Post-test measures in Group A and Group B. There was a significant difference in NPRS as pre mean of pain was 4.58(0.996) and post mean was 0.50(0.07)* in Group A and Group B pre mean was 4.75(1.138) and post mean was 0.00(0.00)* which shows the significant reduction of pain after 6 weeks of intervention. Similarly, there were significant reductions in MODI and EMG shown in figures 1A, 1B, 1C.

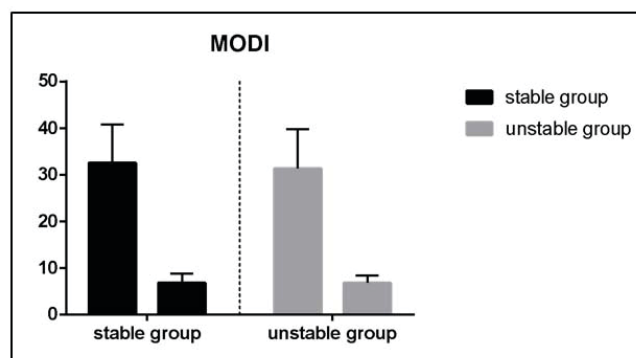


Figure 1A: MODI Pre and Post in Group A (stable group) and B (unstable group) showing means and standard deviation.

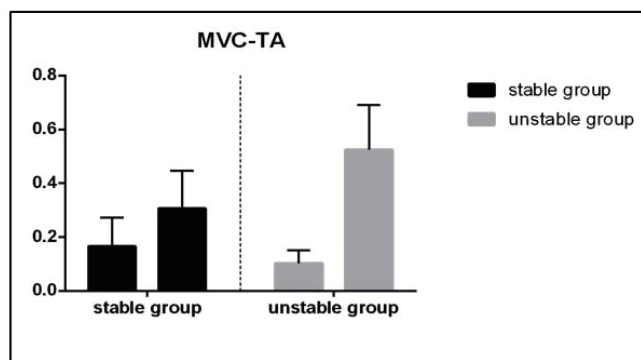


Figure 1B: MVC-EMG of TA Pre and Post in Group A (stable group) and B (unstable group) showing means and standard deviation.

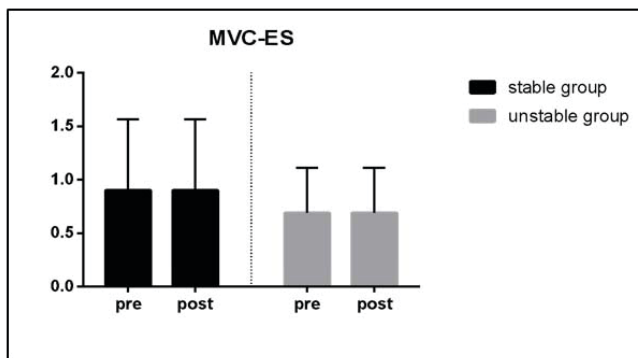


Figure 1C: MVC of ES Pre and Post in Group A (stable group) and B unstable group) showing means and standard deviation.

Analysis of data between the two groups

An independent *t*-test was used to compare post-test criterion measurement between Group-A and Group-B. A significant difference was seen between the groups in Pain (NPRS) and EMG activity of transverse abdominal muscle but there was no significant difference in Functional Disability (MODI) and EMG activity of Erector Spinae as shown in table 2. This reveals that lumbar stabilisation exercises done on Swiss balls were effective in decreasing chronic pain and increasing muscle activity patterns of local core muscles.

DISCUSSION

Patients having non-specific mechanical low back pain show physical deconditioning of the core and manifests as muscle atrophy, decreased muscle strength and endurance. The localised and unilateral cross-sectional area of core muscles was also reduced in these patients. Active rehabilitation of trunk musculature reduced LBP symptoms, increased muscle strength, cross-sectional area and endurance.¹⁸In the current study pain was evaluated by NPRS scale so that subjective pain intensity of patients with CLBP before and after 6 weeks of training can be assessed. The reason for the reduction of pain was due to unbalanced core muscles training which leads to deep muscles activation and improves neuromuscular control. Yoon et al 2013, reported that stabilization exercises help in the reduction of pain by decreasing the signal delivered to the pain receptive tissues such as ligaments and joint capsules and further decrease the load on the lumbar vertebrae and enhance the function of the core stabilizer muscles leads to trunk positional control¹⁶, a result which is similar with our study result. Lee et al., 2014, reported a significant reduction in pain in CLBP after training with Swiss Ball¹², a result that is consistent with our study. Along with that our result also showed that pain intensity significantly decreases Group B than Group A which was due to increased co-contraction pattern and activation in local core muscles.

In this study, the Lumbar stabilization exercise helped in increasing proprioception and co-contraction of core mus-

cle which provide stability to the spine. Therefore emphasis should be on the stabilization exercises instead of strengthening of the muscle in low back patients.¹⁹Similarly trunk stabilizers muscles are more likely activated by unstable surfaces than stable which can be used in low back pain patients.²⁰ There was a significant improvement in MODI in both groups after six weeks of intervention. But there was no significant difference between the two groups. A score less than 20% indicates that functional disability was not regarded as a significant functional disability in the daily life of patients.²¹

Muscle activity of local and global muscle was evaluated by EMG before and after six weeks of intervention and it has been seen that the MVC value of Transverse Abdominis and Erector Spinae significantly improves in both groups. The activity of transverse abdominis showed significant improvement in Group B as compared to another group, while there was no notable difference in MVIC value of Erector Spinae muscle. According to some research, good activation of the local muscles can lead to optimal stabilization of the lower back during basic stabilization exercise (O’Sullivan et al., 2000; Richardson et al., 2004).^{22,9,25} In the study (Escamilia et al.,2005) concluded that local muscles have a greater proprioceptive function and the exercise done on Swiss balls stresses these muscles to a greater extent which lead to improvement in balance.^{23,24}Similarly deep abdominal muscle plays a very important role in providing spinal stability than superficial abdominal muscles. Despite the local muscles having short moment arms, which are deep and tonic muscles functioning as stabilizers of lumbar segments whereas superficial muscles are movement generating muscles that provide overall stability.²

Future studies can be done using resistance exercise using thera-band to provide resistance during LSE on both surfaces. An activity related EMG can be integrated comprising both the local and global muscle Limitations of the study where long term follow up can be taken to determine the reversibility of the result and the result cannot be generalized to the whole population.

CONCLUSION

The result of the study demonstrated that both stable and unstable surfaces significantly improved pain, functional disability and muscle activation pattern of the core muscles. Whereas, exercises performed on unstable surfaces are more effective as they help in achieving trunk stability and increasing the muscle activation pattern of transverse abdominal muscle to a great extent than the exercises done on a stable surface.

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Author's Contribution:

Sheema Saleem: Conceptualisation, data collection, data analysis, manuscript writing, manuscript modification.

Moazzam Hussain Khan: Conceptualisation, data analysis, manuscript modification, corresponding with the editor.

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