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Effectiveness of Aerobic Exercise Versus Core Stability Exercise on Pain and Function in Patients with Mechanical Low Back Pain - A Quasi Experimental Study

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Abstract: ***Background and Need for Study: Mechanical low back pain (MLBP) is a common problem affecting 40% of the population at some point in their life causes significant disability. The most frequently recommended form of treatment for MLBP is exercise. Aerobic exercises work on general health to improve function in MLBP. Core strengthening exercises (CSE), which can address strengthen the weak muscles. The need of the study was to compare the effects of Aerobic exercise and Core strengthening exercise on MLBP. Aim and Objectives : The aim of the study is to compare the effectiveness of aerobic exercise along with conventional therapy and core strengthening exercise along with conventional therapy in patients with MLBP. Methodology: 30 participants with Mechanical low back pain were allocated into Group A (N=15) Aerobic exercise and Group B(N=15) core strengthening exercise. . Pain and function were taken using the Numerical Pain Rating Scale and Back Pain Functional Scale at baseline and after 4 weeks. Result: The IBM SPSS version 26 was used for the statistical analysis (CI= 95%). The result showed that within-group analysis showed significant improvement in pain and function, but between-group analysis showed aerobic exercise was significantly more effective compared to CSE (p<0.05) after 4 weeks. Conclusion: The result indicate that Aerobic exercises are more effective than core strengthening exercises for lowering pain levels and improve function.***

Keywords: Mechanical low back pain, Aerobic exercise, core strengthening exercises, and, MODI

1. Introduction

Mechanical low back pain (MLBP) is one of the most prevalent musculoskeletal disorders affecting adults worldwide and is a leading cause of disability, work absenteeism, and reduced quality of life. It is defined as pain originating from the lumbar spine or its supporting structures, such as muscles, ligaments, joints, or intervertebral discs, without identifiable serious pathology such as fracture, infection, or malignancy.[1,2] The lifetime prevalence of low back pain is reported to be as high as 80%, with mechanical causes accounting for the majority of cases encountered in clinical practice.[3] Persistent or recurrent mechanical low back pain often results in functional limitations, decreased physical activity levels, and psychological distress, thereby placing a substantial socioeconomic burden on individuals and healthcare systems.[4]

Exercise therapy is widely recognised as a first-line conservative management strategy for mechanical and non-specific low back pain.[5,6] Clinical guidelines consistently recommend exercise interventions due to their ability to reduce pain intensity, improve functional capacity, and prevent recurrence.[5,7] Various forms of exercise, including aerobic training, strengthening, flexibility, and motor control exercises, have been employed with varying degrees of success. However, there remains ongoing debate regarding the most effective type of exercise intervention for optimising outcomes in patients with mechanical low back pain.[6,8]

Aerobic exercise involves rhythmic, repetitive movements of large muscle groups that enhance cardiovascular endurance, such as walking, cycling, or treadmill exercise.[9] Aerobic training has been shown to improve blood circulation, enhance oxygen delivery to spinal structures, reduce muscle stiffness, and promote the release of endogenous opioids, thereby contributing to pain modulation.[10,11] Additionally, aerobic exercise has beneficial effects on psychosocial factors such as anxiety, depression, and fear-avoidance beliefs, which are commonly associated with chronic low back pain.[12] Systematic reviews and randomised controlled trials have demonstrated that aerobic exercise can significantly reduce pain intensity and disability while improving overall physical function in individuals with chronic low back pain.[13,14]

In contrast, core stability exercise emphasises the activation and strengthening of deep trunk muscles, including the transversus abdominis, multifidus, pelvic floor muscles, and diaphragm, with the aim of enhancing spinal stability and neuromuscular control.[15] Impaired activation and delayed recruitment of these stabilising muscles have been identified in individuals with mechanical low back pain, potentially contributing to spinal instability and recurrent symptoms.[16] Core stability training seeks to restore proper

motor control, reduce excessive spinal loading, and improve postural alignment during functional activities.[15,17] Several studies have reported significant improvements in pain and functional outcomes following core stability exercise programs when compared to conventional or general exercise interventions.[18,19]

Despite the established benefits of both aerobic exercise and core stability exercise in the management of low back pain, direct comparisons between these two modalities in patients with mechanical low back pain remain limited and inconclusive. Some studies suggest that core stability exercises may offer superior short-term improvements in pain and function, while others indicate that aerobic exercise may be equally or more effective due to its holistic physiological and psychological benefits.[13,20] Given the widespread use of both exercise approaches in physiotherapy practice, there is a need for comparative research to determine their relative effectiveness in reducing pain and improving functional ability in patients with mechanical low back pain.

The present study aims to compare the effectiveness of aerobic exercise versus core stability exercise on pain intensity and functional outcomes in patients with mechanical low back pain. The findings of this research may assist clinicians in selecting evidence-based exercise interventions and optimising rehabilitation strategies for this common and disabling condition.

2. Materials and Methodology

The present study was designed as a quasi-experimental study to evaluate the effectiveness of different exercise interventions in patients with mechanical low back pain. A convenience sampling method was employed to recruit participants from an institutional musculoskeletal physiotherapy outpatient department (OPD). The study population comprised individuals diagnosed with mechanical low back pain who fulfilled the inclusion criteria. A total of 30 participants were enrolled in the study and were equally allocated into two groups, with 15 participants in each group. The intervention was administered four times per week over a period of four weeks for both groups, and outcomes were assessed before and after the treatment duration.

Pain intensity and functional ability were assessed using standardised outcome measures. Pain severity was evaluated using the Numerical Pain Rating Scale (NPRS), which is a reliable and valid tool for measuring subjective pain intensity. Functional status related to low back pain was assessed using the Back Pain Functional Scale (BPFS), which measures the impact of back pain on an individual's ability to perform daily functional activities. Both outcome measures were recorded before and after the intervention period to determine the effectiveness of the treatment.

Participants were selected for the study based on predefined inclusion and exclusion criteria. **Inclusion criteria** comprised individuals aged between 30 and 45 years, including both male and female participants, diagnosed with mechanical low back pain. Participants were required to have a Numerical Pain Rating Scale (NPRS) score ranging from 4 to 7, indicating moderate pain intensity, and a Modified Oswestry Disability Index (MODI) score reflecting minimum to moderate disability, limited to a maximum of 40%. **Exclusion criteria** included participants presenting with disc pathology associated with radicular pain, a history of spinal fracture or previous spinal surgery, progressive motor or sensory neurological deficits, or a history of significant spinal trauma. Individuals diagnosed with tuberculosis of the spine were also excluded from the study.

3. Intervention

Participants allocated to the aerobic exercise group (Group A) underwent a structured aerobic exercise program four times per week for a total duration of four weeks. Each session commenced with a standardised warm-up period performed at mild to moderate intensity to prepare the musculoskeletal system and reduce the risk of injury. The warm-up consisted of comprehensive self-stretching exercises targeting the lumbar flexors, lumbar extensors, and lateral flexors of the lumbar spine.

Each stretch was held for 30 seconds with three repetitions, allowing a rest interval of 10 seconds between repetitions, with a total warm-up duration of approximately two minutes. [21, 22]

Following the warm-up, participants performed aerobic exercise in the form of stationary cycling. Exercise intensity was prescribed using the heart rate reserve (HRR) method, ensuring individualised cardiovascular loading. Initially, the target heart rate was set between 40% and 60% of HRR and was progressively increased by 5% per week, up to a maximum of 85%, depending on participant tolerance and symptom response. [23] The aerobic exercise duration ranged from 20 to 30 minutes per session. Heart rate was monitored throughout the session to maintain the prescribed intensity. Aerobic training was selected due to its demonstrated effectiveness in reducing pain, improving functional capacity, enhancing spinal circulation, and modulating pain perception through endogenous opioid release.[24,25]

Each session concluded with a cool-down period performed at mild to moderate intensity. The cool-down phase included the same self-stretching exercises for lumbar flexors, extensors, and side flexors, performed for two minutes using 30- second holds with three repetitions and 10-second rest intervals. This structured aerobic exercise protocol was designed to safely improve cardiovascular fitness while reducing pain intensity and improving functional ability in patients with mechanical low back pain.[26,27]

Calculation of VO_2 Max and Target Heart Rate VO_2 Max Estimation (Submaximal Formula)

VO_2 max was estimated using the standard age-predicted formula:

VO_2 max (ml/kg/min)=15.3×(HRma xH Rrest)\ VO_2 max (ml/kg/min)} = 15.3 \times \left(\frac{HR_{max}}{HR_{rest}}\right)VO_2 max (ml/kg/min)=15.3×(HRrestHRmax) Where:

- **HRmax** = 220 − age (years)
- **HRrest** = resting heart rate (beats per minute)

Target Heart Rate (Karvonen Formula)
Target HR=[(HRmax−HRrest)×%Intensity]+HRrest\{Target HR} = [(HR_{max} - HR_{rest}) \times \% \text{Intensity}] + HR_{rest}Target HR=[(HRmax−HRrest)×%Intensity]+HRrest Where:

- **HRmax** = 220 − age
- **HRrest** = resting heart rate
- **% Intensity** = 40–60% initially, progressed up to 85%

This method allows accurate prescription of aerobic exercise intensity based on individual cardiovascular capacity.[23] Participants allocated to Group B received a structured core stability exercise program.

1) **Pressure biofeedback–assisted core exercises performed in supine and prone positions :** In the supine position, a pressure biofeedback unit was placed under the lumbar spine and inflated to 40 mmHg. Participants were instructed to gently draw in the lower abdomen without pelvic movement, aiming to reduce the pressure by 6–10 mmHg and hold the contraction for 10 seconds while breathing normally. In the prone position, the cuff was placed under the abdomen and inflated to 70 mmHg, and participants were instructed to draw the abdomen away from the cuff, maintaining a pressure reduction of 6–10 mmHg.[28]
2) **Multifidus muscle activation exercise:** performed in prone lying. Participants were instructed to gently swell the muscles adjacent to the lumbar spinous processes without producing spinal movement or pelvic tilting. Low- load isometric contractions were maintained for 10 seconds and repeated for 10 repetitions. [29]
3) **Pelvic floor muscle exercise:** Participants were instructed to contract the pelvic floor muscles as if attempting to stop the flow of urine, while avoiding activation of superficial abdominal or gluteal muscles. Each contraction was held for 10 seconds, followed by adequate relaxation, and repeated for 10 repetitions. [30]
4) **Single-leg standing exercises on a foam surface:** Participants stood on one leg on an unstable foam surface while maintaining an upright posture and engaging the core muscles. The position was held for 20–30 seconds and repeated for multiple trials on each leg.[31]
5) **Tandem standing with external perturbations**: Participants have to positioning one foot directly in front of the other while the participant executed rapid arm movements. These perturbations required anticipatory and reactive core muscle activation to maintain balance. Each trial was maintained for 20–30 seconds, focusing on controlled trunk alignment and stability.[32]
6) **Front and side plank exercises**: Front planks were performed in prone lying with forearm support, maintaining a neutral spine, while side planks were performed in side-lying with body weight supported on one forearm and the lateral aspect of the foot. Each plank position was held for 20–30 seconds and progressively increased based on tolerance.[29,33]

Outcome Measurement

Intensity of Pain Numerical Pain Rating Scale (NPRS) : [32,33,34]

The intensity of pain was assessed using the numerical pain rating scale (NPRS) ranging from 0-10 points, with higher scores indicating greater pain intensity The 11- point numerical scale ranges from '0' representing "no pain" to 10 representing the "worst pain imaginable". The NPRS was administered graphically for self-completion. Each participant was asked to indicate the numeric value on the segmented scale that best describes their pain intensity Each participant was evaluated before the first session and after the last session NPRS has been validated and determined to be a reliable scale for pain assessment in LDH. The test-retest reliability ® of NPRS was high at 0.90

Functional Disability (Back Pain Functional Scale – BPFS) [35]

The Back Pain Functional Scale (BPFS) is a self-reported measure used to assess functional ability in individuals with low back pain. It consists of 12 items related to daily activities, each scored on a 6-point scale from 0 (unable to perform) to 5 (no difficulty). The total score ranges from 0 to 60, with higher scores indicating better function and lower disability. The BPFS is a valid and reliable outcome measure, demonstrating excellent test–retest reliability (r = 0.99).

Data Analysis:

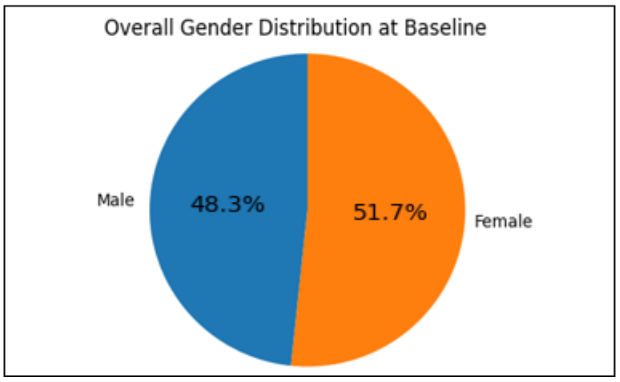
All data were analysed using statistical software SPSS version 26. Before applying statistical tests, data were screened for normal distribution. All the outcome measures were analysed at baseline and after 4 weeks of the treatment, by using appropriate statistical tests. The level of significance was kept at 5%. Changes in outcome measures were analysed within groups as well as between groups. Intra-group comparison of pre and post treatment scores of Numerical Pain Rating Scale (NPRS) was done by a parametric paired T - test and non - parametric and the Back Pain Functional Scale (BPFS) was done. Inter-group comparison of pre and post difference of the Numerical Pain Rating Scale (NPRS) was done by Unpaired T- test, Back Pain Functional Scale (BPFS) was done by using Mann Whitney U test.

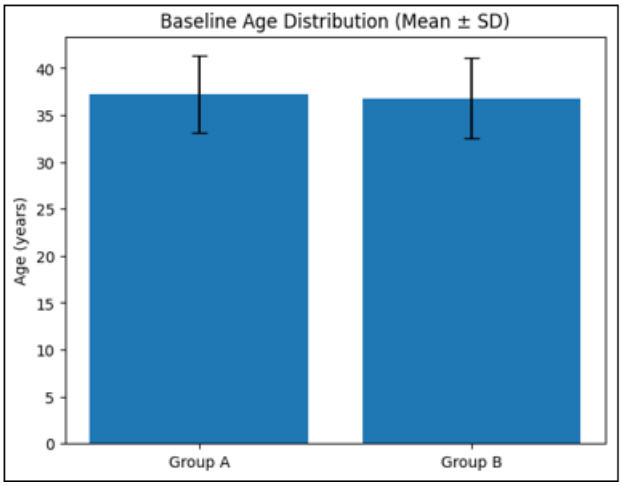
4. Result

The general characteristics are shown in Table 1. In the preliminary examination among Groups A and B , there is no significant differences were observed in the data among the groups, thus making the data homogenous. 3 participants were excluded because they did not meet the experimental standards, and 2 participants were declined to participate. Finally, statistical analysis was conducted on 30 participants each in the Group A and Group B.

Table 1: The Baseline Characteristics of Participants
The values are presented mean (SD)

Variable	Group A (n = 15)	Group B (n = 15)	*p* value
Age (years)	37.2 ± 4.1	36.8 ± 4.3	0.78
Gender			
Male, n (%)	7 (46.7%)	8 (53.3%)	0.72
Female, n (%)	8 (53.3%)	7 (46.7%)	





Graph 1 & 2: Gender and Age Distribution in Group A &B

The above table 1, Graph1& 2 shows the mean age and gender of both the groups. The age & gender of both the groups does not shows any statistical significance difference, providing that the groups are homogenous in terms of age.

Table 2: Inter Group Comparision of Pre Value of Group A & B

Outcome Measure	Group A	Group B	t / Z value	p-value
NPRS (0–10)	6.42 ± 1.01	6.38 ± 0.98	t = 0.20	0.84
BPFS (0–60)	33.15 ± 4.2	33.48 ± 4.12	t = −0.38	0.71

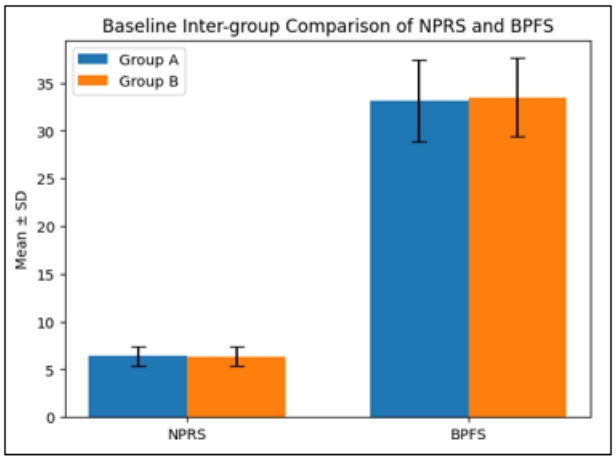


Table 2 & Graph 3 shows the baseline characteristics of pre- treatment variables of group A & B. Differences in the pre-treatment mean values of both the groups were analysed using a parametric Unpaired T test for NPRS and Non - parametric Man Whitney u Test for Back Pain Functional Scale (BPFS) and where the p value of all variable is > 0.05. It shows that there is no statistically significant difference between the pre- treatment score of NPRS Back Pain Functional Scale (BPFS) between group A & B. Hence, it proves that the pre outcome score of group A & B are homogenous.

Table 3: Mean and Standard Deviation of Values Obtained Before and After Treatment for Group A and B with P Values

		Mean	SD	t/Z Value	P Value
NPRS G-A	Pre	6	1.6	11.8	0.001
	Post	5.66	0.81		
NPRS G-B	Pre	5.66	1.5	6.97	0
	Post	2.66	1.39		
BPFS G-A	Pre	16.08	8.35	-3.44	0.001
	Post	15.2	4.44		
BPFS G-B	Pre	15.06	5	-3.344	0.001
	Post	11	7.08		

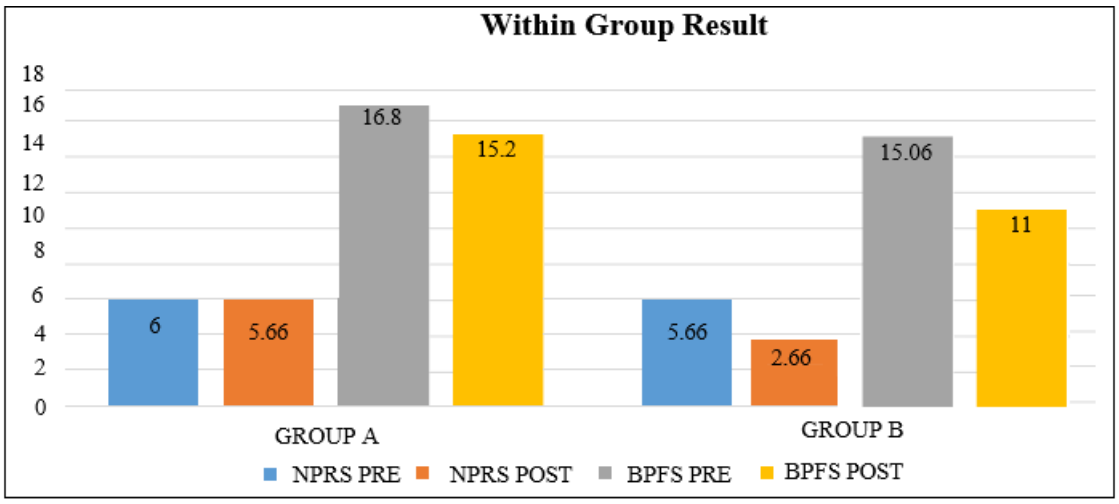
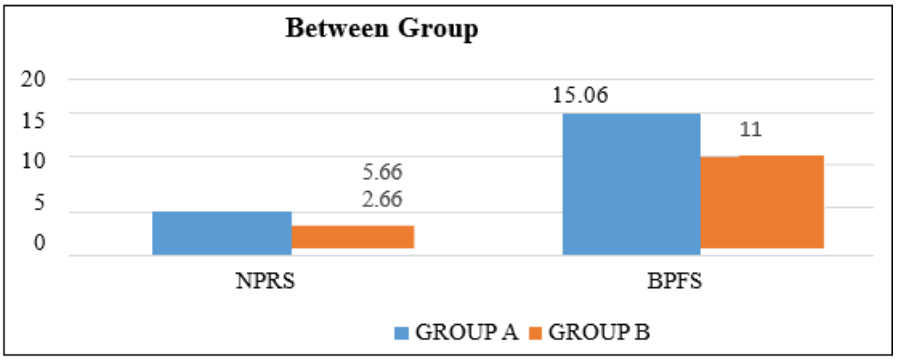


Table 3 & Graph 4 shows the comparison of pre & post treatment scores of NPRS, and BPFS of Group A & B. Differences in the pre and post treatment mean values of group A & B analysed using a parametric Paired T- test test for NPRS, and BPFS, Where the p value of all variable is <0.05. It shows that there is statistically significant

difference between the pre and post treatment score of NPRS and BPFS of group A & B.

Table 4: Post Test Comparison of NPRS and BPFS Between Group A & B

	Group A		Group B		T/Z Value	P Value
Variables	Mean	SD	Mean	SD		
NPRS	5.66	0.81	2.66	1.39	7.188	0.000
BPFS	15.06	5	11	7.08	-3.189	0.000



The above table 4 & Graph 5 shows the comparison of mean of difference of post intervention variables of group A & B. Differences in the mean of difference of post intervention values of both the groups were analyzed using a parametric Unpaired T test for NPRS, and Back pain functional scale (BPFS)where the p value of all variable is < 0.05. It shows that there is statistically significant difference in the improvement between the groups

5. Discussion

Improvement in the activation ratio of the deep abdominal muscles, particularly the transversus abdominis and internal oblique relative to the rectus abdominis, reflects enhanced recruitment of the local stabilizing system of the trunk, which plays a fundamental role in maintaining segmental spinal stability and neuromuscular control.[36] The transversus abdominis is considered the primary local stabilizer of the lumbar spine because its horizontal fiber orientation and fascial attachments enable it to increase intra-abdominal pressure and tension the thoracolumbar fascia, thereby providing segmental stabilization of the vertebral column.[37]When the activation of the transversus abdominis and internal oblique muscles increases relative to the rectus abdominis, a shift occurs from a global mobilizing strategy toward a local stabilization strategy, which enhances the functional efficiency of the segmental trunk muscles.[38]

This improvement in deep muscle recruitment enhances the coordinated activity of segmental stabilizing muscles such as the transversus abdominis, multifidus, and internal oblique, which collectively contribute to dynamic spinal stability during functional movement.[39] Segmental stabilizing muscles act synergistically to maintain optimal intervertebral alignment and control micromovements of the spine, thereby reducing excessive loading and improving biomechanical efficiency during postural and dynamic activities. Enhanced recruitment of these deep stabilizers also facilitates improved neuromuscular coordination between the trunk and extremities, which is essential for efficient movement patterns and injury prevention. Training interventions that emphasize deep core activation are known to increase the activation ratio and improve the timing of transversus abdominis contraction, indicating improved feed-forward motor control of the trunk during limb movements.[40]

In addition to neuromuscular adaptations, repeated activation of trunk musculature during exercise promotes metabolic adaptations in skeletal muscle, including increased oxidative capacity and improved mitochondrial efficiency. These metabolic adaptations enhance the ability of skeletal muscle fibers to utilize oxygen for ATP production through oxidative phosphorylation, thereby improving muscular endurance and delaying the onset of fatigue.[35] Improved oxidative capacity of skeletal muscle also contributes to better neuromotor performance, as muscles with higher aerobic capacity are able to sustain coordinated contractions over prolonged periods.[36]

Core strengthening exercises showed an improvement in the activation ratio of the transversus abdominis and internal oblique relative to the rectus abdominis muscle, indicating enhanced recruitment of the deep stabilizing musculature of the trunk. The transversus abdominis and internal oblique are considered key components of the local stabilization system of the lumbar spine, and their preferential activation plays a crucial role in maintaining spinal stability during functional movements. Core strengthening exercises specifically target these deep abdominal muscles and promote selective activation, which helps in restoring the balance between local stabilizing muscles and global mobilizing muscles of the trunk.[41]

The transversus abdominis contributes to spinal stability through its horizontal fiber orientation and its anatomical connection with the thoracolumbar fascia, which allows it to increase intra-abdominal pressure and provide circumferential support to the lumbar spine. Increased activation of the internal oblique also assists in augmenting trunk stability by working synergistically with the transversus abdominis to control rotational and lateral forces acting on the lumbar spine.[42]

Improvement in the activation ratio of these muscles relative to the rectus abdominis suggests a shift toward a more

efficient motor control strategy in which deep stabilizing muscles are recruited earlier and more effectively than superficial global muscles. This neuromuscular adaptation is essential for maintaining segmental stability of the spine because the deep abdominal muscles provide anticipatory feed-forward activation before limb movement, thereby stabilizing the trunk and minimizing excessive intervertebral motion.[43]

Core strengthening exercises also enhance neuromuscular coordination and motor control by improving the timing and synchronization of trunk muscle activation during postural and dynamic tasks. Furthermore, repeated activation of these muscles during training leads to physiological adaptations in skeletal muscle, including improved oxidative capacity, enhanced mitochondrial function, and increased resistance to fatigue. These metabolic and neuromuscular adaptations collectively contribute to improved muscular endurance, better postural control, and enhanced functional performance in individuals performing core stabilization exercises.[44]

Therefore, the observed improvement in the activation ratio of the transversus abdominis and internal oblique relative to the rectus abdominis following core strengthening exercises may represent an important mechanism through which trunk stability, neuromuscular efficiency, and functional performance are enhanced.[45]

6. Conclusion

This study concluded that Aerobic exercises has beneficial effects for lowering pain level and reducing functional impairment comparing with core strengthening exercise.

References

[1] Andersson GB. Epidemiological features of chronic low-back pain. Lancet. 1999;354(9178):581-585.
[2] Airaksinen O, Brox JI, Cedraschi C, et al. European guidelines for the management of chronic nonspecific low back pain. Eur Spine J. 2006;15(Suppl 2):S192-S300.
[3] Hoy D, Bain C, Williams G, et al. A systematic review of the global prevalence of low back pain. Arthritis Rheum. 2012;64(6):2028-2037.
[4] Hartvigsen J, Hancock MJ, Kongsted A, et al. What low back pain is and why we need to pay attention. Lancet. 2018;391(10137):2356-2367.
[5] Qaseem A, Wilt TJ, McLean RM, Forciea MA. Noninvasive treatments for acute, subacute, and chronic low back pain. Ann Intern Med. 2017;166(7):514-530.
[6] Hayden JA, van Tulder MW, Malmivaara A, Koes BW. Exercise therapy for treatment of non-specific low back pain. Cochrane Database Syst Rev. 2005;CD000335.
[7] Delitto A, George SZ, Van Dillen LR, et al. Low back pain clinical practice guidelines. J Orthop Sports Phys Ther. 2012;42(4):A1-A57.
[8] Saragiotto BT, Maher CG, Yamato TP, et al. Motor control exercise for chronic non-specific low back pain. Cochrane Database Syst Rev. 2016; CD012004.
[9] American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription. 10th ed. Philadelphia: Wolters Kluwer; 2018.
[10] Meng XG, Yue SW. Efficacy of aerobic exercise for treatment of chronic low back pain: a meta-analysis. Am J Phys Med Rehabil. 2015;94(4):358-365.
[11] Koltyn KF. Analgesia following exercise. Sports Med. 2000;29(2):85-98.
[12] Geneen LJ, Moore RA, Clarke C, et al. Physical activity and exercise for chronic pain in adults. Cochrane Database Syst Rev. 2017; CD011279.
[13] Shnayderman I, Katz-Leurer M. An aerobic walking programme versus muscle strengthening programme for chronic low back pain. Clin Rehabil. 2013;27(3):207-214.
[14] Gordon R, Bloxham S. A systematic review of the effects of exercise on chronic low back pain. Healthcare (Basel). 2016;4(2):22.
[15] Panjabi MM. The stabilizing system of the spine. Part I: function, dysfunction, adaptation. J Spinal Disord. 1992;5(4):383-389.
[16] Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain. Spine. 1996;21(22):2640-2650.
[17] Akuthota V, Nadler SF. Core strengthening. Arch Phys Med Rehabil. 2004;85(3 Suppl 1):S86-S92.
[18] Wang XQ, Zheng JJ, Yu ZW, et al. A meta-analysis of core stability exercise versus general exercise for chronic low back pain. Pain Pract. 2012;12(3):189-198.
[19] Smith BE, Littlewood C, May S. An update of stabilisation exercises for low back pain. Man Ther. 2014;19(6):484- 492.
[20] Searle A, Spink M, Ho A, Chuter V. Exercise interventions for the treatment of chronic low back pain. Clin Rehabil. 2015;29(12):1155-1167.
[21] Kisner C, Colby L. *Therapeutic exercise: foundations and techniques*. 6th ed. Philadelphia: F.A. Davis; 2012.
[22] McArdle WD, Katch FI, Katch VL. *Exercise physiology: nutrition, energy, and human performance*. 8th ed. Philadelphia: Lippincott Williams & Wilkins; 2015.
[23] American College of Sports Medicine. *ACSM's guidelines for exercise testing and prescription*. 10th ed. Philadelphia: Wolters Kluwer; 2018.
[24] Meng XG, Yue SW. Efficacy of aerobic exercise for treatment of chronic low back pain: a meta-analysis. *Am J Phys Med Rehabil*. 2015;94(4):358-365.
[25] Koltyn KF. Analgesia following exercise: a review. *Sports Med*. 2000;29(2):85-98.
[26] Shnayderman I, Katz-Leurer M. An aerobic walking programme versus muscle strengthening programme for chronic low back pain. *Clin Rehabil*. 2013;27(3):207-214.
[27] Gordon R, Bloxham S. A systematic review of the effects of exercise on chronic low back pain. *Healthcare (Basel)*. 2016;4(2):22.
[28] Richardson CA, Jull GA, Hodges PW, Hides JA. *Therapeutic exercise for spinal segmental stabilization*. Edinburgh: Churchill Livingstone; 1999.
[29] Hides JA, Richardson CA, Jull GA. Multifidus muscle

recovery is not automatic after resolution of acute, first- episode low back pain. *Spine*. 1996;21(23):2763–2769.
[30] Sapsford R, Hodges P. Contraction of the pelvic floor muscles during abdominal maneuvers. *Arch Phys Med Rehabil*. 2001;82(8):1081–1088.
[31] Behm DG, Colado JC. The effectiveness of resistance training using unstable surfaces. *Sports Med*. 2012;42(8):665– 692.
[32] Hodges PW, Moseley GL. Pain and motor control of the lumbopelvic region. *J Electromyogr Kinesiol*. 2003;13(4):361–370.
[33] McGill SM. Low back stability: from formal description to issues for performance and rehabilitation. *Exerc Sport Sci Rev*. 2001;29(1):26–31.
[34] Hjermstad MJ, Fayers PM, Haugen DF. Studies comparing numerical rating scales and visual analogue scales for assessment of pain intensity in adults: a systematic review. *J Pain Symptom Manage*. 2011
[35] Stratford PW, Binkley JM, Riddle DL. Development and initial validation of the Back Pain Functional Scale. *Phys Ther*. 2000;80(4):321–330.
[36] Cholewicki J, Juluru K, McGill SM. Intra-abdominal pressure mechanism for stabilizing the lumbar spine. **J Biomech.** 1999;32(1):13-17.
[37] Brown SH, Ward SR, Cook MS, Lieber RL. Effect of abdominal muscle coactivation on lumbar spine stability. **J Biomech.** 2011;44(5):963-968.
[38] Oliva-Lozano JM, Muyor JM. Core muscle activity during physical fitness exercises: a systematic review. **Int J Environ Res Public Health.** 2020;17(12):4306.
[39] Selkow NM, Eck MR, Rivas S. Transversus abdominis activation and timing improves following core stability training: a randomized trial. **Int J Sports Phys Ther.** 2017;12(7):1048-1056.
[40] McGill SM. **Low Back Disorders: Evidence-Based Prevention and Rehabilitation.** 3rd ed. Champaign (IL): Human Kinetics; 2016.
[41] Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain. **Spine (Phila Pa 1976).** 1996;21(22):2640-2650.
[42] Hodges PW, Richardson CA. Contraction of the abdominal muscles associated with movement of the lower limb. **Phys Ther.** 1997;77(2):132-142.
[43] McGill SM. **Low Back Disorders: Evidence-Based Prevention and Rehabilitation.** 3rd ed. Champaign (IL): Human Kinetics; 2016.
[44] Akuthota V, Nadler SF. Core strengthening. **Arch Phys Med Rehabil.** 2004;85(3 Suppl 1):S86-S92.
[45] Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. **Sports Med.** 2006;36(3):189-198.
[46] Panjabi MM. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. **J Spinal Disord.** 1992;5(4):383-389.

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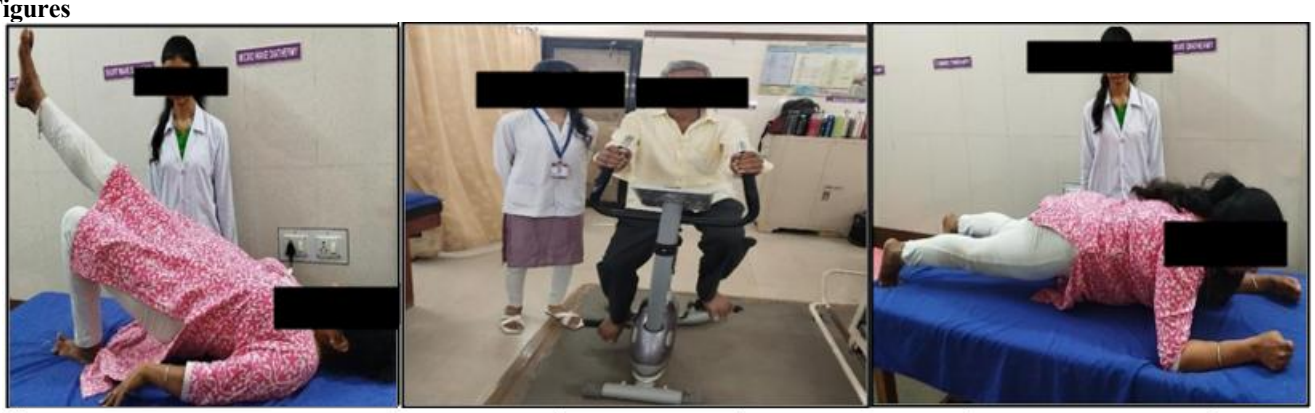
Figures



Pelvic Floor Muscle Exercise | Cycling | Plank exercise