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Effects of Core Strengthening on Cardiovascular Fitness, Flexibility and Strength on Patients with Low Back Pain

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Abstract

Background: Back pain is a common complaint for people of all ages. Chronic back pain sufferers have been estimated to constitute ¼ of the population. People who sit for prolonged periods of time are predisposed to have low back pain problem frequently.

Methodology: In this study, 30 patients were selected according to inclusion and exclusion criteria and were assigned into two groups: experimental group and control group. The experimental group was given core strengthening exercises and control group was given conventional exercises. The intervention was followed daily for 4 weeks. Prior to the exercise and after every week VO_{2max}, flexibility and strength were evaluated as outcome measure.

Results: Both the groups had significant effect on VO_{2max}, flexibility and strength at the end of 4th week ($p<0.05$). Cardiovascular fitness, flexibility and strength improved more in the experimental group.

Conclusion: Core strengthening exercise improves muscle imbalances, posture and enhances cardiovascular fitness, flexibility and strength in patients with low back pain.

Keywords: Low back pain; Core strengthening; Flexibility; Strength

Introduction

Low back pain is a leading cause of disability, contributing to decreased cardiovascular fitness, muscular strength, flexibility, bone density, and disk nutrition; increased spinal segment stiffness and depression which are also associated with inactivity. It is the most common cause of disability in people younger than 45 years of age. Despite a decrease in symptoms, these patients have anatomic and functional changes that increase their chance of reinjury [1]. Low back pain problem are usually linked to two causes: first lifestyle, which indicates stress, lack of exercise and poor posture and second physical injury. Stress can be precursor to low back pain by upsetting the nervous system and causing muscles to go into spasm. Bending lifting and twisting movements can lead to muscle strain and ligament sprain, most commonly associated with acute low back pain [2,3]. Many people have back pain whether its upper back pain or lower back pain and this may be partly caused by weak abdominal muscles. Weak abdominal muscles are correlated with a high incidence of back injury. The upper and lower back is composed of individual segments of the spinal cord, if it is not kept in the proper position than it can cause undue strain on ligaments, tendons, and muscles [4]. Decreased muscle flexibility, trunk strength and poor muscle endurance have been reported to be associated with back pain issues [3,5].

Prevention of chronic or recurring back pain can be done by learning and practicing good postural habits, increasing strength and endurance of the muscles that support the spine. Current medical literature suggests that exercise appears to exert a neutral effect or may even slightly reduce the risk of future back injuries. The benefits of exercise are profound and include improved cardiovascular fitness, muscle strength, flexibility, and endurance [1]. The goals of these exercises is to improve impaired back function, decrease back pain symptoms and minimize the disability by diminishing excessive fears and concerns about back pain [6].

Core strengthening has a theoretical basis in treatment and prevention of various musculoskeletal conditions. The “core” has been described as a box with the abdominals in the front, paraspinals and gluteals in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom. Core serves as a muscular corset that works as a unit to stabilize the body and spine [7]. It also describes the training of muscle around the lumbar spine and the abdomen and functions essentially to maintain spinal stability and pelvic balance [8]. Weakness in any of the core muscles can affect spinal stability and leave the lower back vulnerable to injury. Core stabilization exercise through effective abdominal training helps to increase the strength, stability, balance and stamina. So the training of trunk or spinal stabilizers is therefore supposed to helpful in improving the endurance of trunk extensors or mobilizers and preventing development of backaches in future [9].

Cardiovascular training can result in improved blood flow to muscles, enhanced VO_{2max} (maximal oxygen consumption during exercise), lower heart rate for a given level of exertion. Flexibility is defined as the ability to move a single joint or series of joints through an unrestricted pain free range of motion. Muscles prone to tightness in LBP patients include erector spinae, quadratouslumborum etc., therefore the goal of a rehabilitation program for LBP is to correct muscle weakness and imbalances with strengthening exercises. Strength of core muscles are found to be affected in the patients with LBP and most commonly multifidi muscles are found to be atrophied [1]. Therefore, core strengthening has been promoted as a preventive regimen, and a rehabilitation program for enhancing various lumbar spine and musculoskeletal injuries.

Method

Participant's

30 patients participated aged between 20-40 years, were randomly recruited through chit method from OPD of SBSPGI and Bala Pritam Hospital Patel Nagar, Dehradun. They were assigned one of the two groups through a randomized protocol experimental group (n=15) or a control group (n=15). Patients suffering from chronic mechanical low back pain were included. Patients with back injury, radiating pain, PIVD, scoliosis, spinal injury, tumour, spondylolisthesis and spondylosis were excluded. A written consent was taken from each subject before participation and whole research was performed after the clearance from the institutional review board. Those who fulfilled the symptomatic criteria underwent a physical examination of Harvard Step Test for $VO2_{max}$, flexibility test and strength test as outcome measure. The experimental group receives core strengthening exercise and control group receives conventional exercise for 4 weeks. The data was measured at starting day, 1st week, 2nd week, 3rd week and 4th week.

Experimental protocol

For cardiovascular fitness, VO_{2max} was measured by Harvard Step Test [10]. A 17 inch bench and a stopwatch were taken and the patients were asked to step up and step down on the bench for 1minute. After completion of one minute heart rate of the patients was taken manually and was recorded as pulse. Then VO_{2max} was calculated by a formula described by Modified Queens College Step Test for Maximum Oxygen Consumption: VO2max(ml/kg/min)=65.81-(0.1847 × step test pulse rate, beats/minute) [11].

Flexibility of trunk flexors was measured by asking the patient to stand upright in a neutral position. Then C7 and S1 vertebra were palpated and marked with a pen and distance between them was measured with the help of an inch tape. Then the patient was asked to flex forward as far as possible with pelvis stabilized. The length between the C7 and S1 was re-measured and the difference in length was recorded as trunk flexion flexibility [12].

Strength of abdominal muscles was checked by asking the patient to perform curl-up on a mat. The patient was placed supine, with knees bent at an angle of approximately 140°, feet placed flat on the floor, legs slightly apart, and arms straight and parallel to the trunk with palms of hands resting on the mat. The fingers were stretched out and the head in contact with the mat. After the correct position was assumed, we placed a measuring strip of 35 inches long and 4.5 inches in width on the mat under patient's leg so that his fingertips just rested on the nearest edge of the measuring strip. Then patient was asked to perform curl-ups. Scoring was done by counting the number of maximum curls they were able to perform in 30 seconds [13].

These values are recorded as readings of patients at 0 day, 1st week, 2nd week, 3rd week and 4th week. Core strengthening exercises and conventional exercises were given to the patients.

For experimental group core strengthening exercise including basic crunches, abdominal crunches, bridging, one-leg bridging, prone planks and side planks were given and for control group conventional exercises including rest and relax, knee to chest, cat and camel and quadruped were given for 4 weeks. Each exercise was repeated 10 times with 10 seconds hold (Figures 1-9).

For Experimental group

Figure 1: Basic Crunches.

Figure 2: Abdominal crunches.

Figure 3: Bridging.

Figure 4: One leg bridging.

Figure 5: Side plunk.

Figure 6: Prone plunk.

For Control Group

Figure 7: Knee to chest.

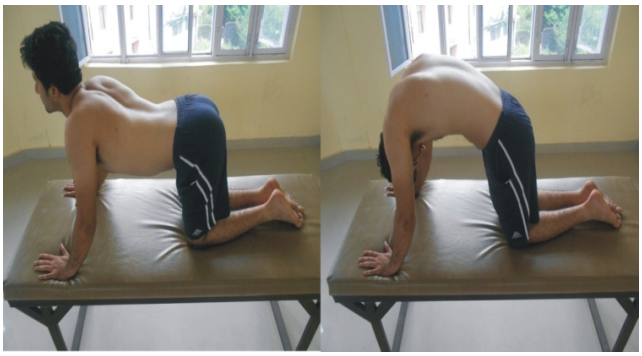


Figure 8: Cat and camel exercise.

Figure 9: Quadruped exercise.

Statistical analysis

The data was analysed using SPSS 17.0 for windows. Independent sample t-test was performed to see any difference between the groups. One way analysis of variance (ANOVA) post-hoc Tukey test were used to determine if there was any difference in 0 day, 1st week, 2nd week, 3rd week and 4th week. The significance level was set at $p<0.05$.

Results

Independent sample t-test between the groups showed significant difference in flexibility, strength and VO_{2max} at 4th week (Table 1). The result of one way analysis of variance (ANOVA) within the experimental group (Group-A) showed significant difference. (Table 2) One way analysis of variance (ANOVA) within the control group (Group-B) showed significant difference in all the variables viz. flexibility, strength and VO_{2max} (Table 3 and Graphs 1-5).

	Mean	SEM	t value	p value
Flexibility 0 day	1.0667	0.56807	1.878	0.71
Flexibility 4th week	2.3667	0.86005	2.752	0.010
Strength 0 day	1.4667	1.16809	1.256	0.220
Strength 4th week	3.8667	1.54406	2.504	0.018
VO2max0 day	0.8227	1.15360	0.713	0.482
VO2max4th week	3.4420	0.90902	3.786	0.001

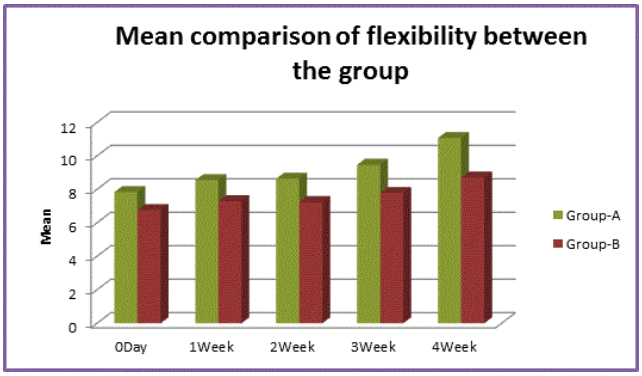
Table 1: Independent samples t-test between the groups.

	F value	p value
Flexibility	4.261	0.004
Strength	40.891	0
VO2max	51.869	0

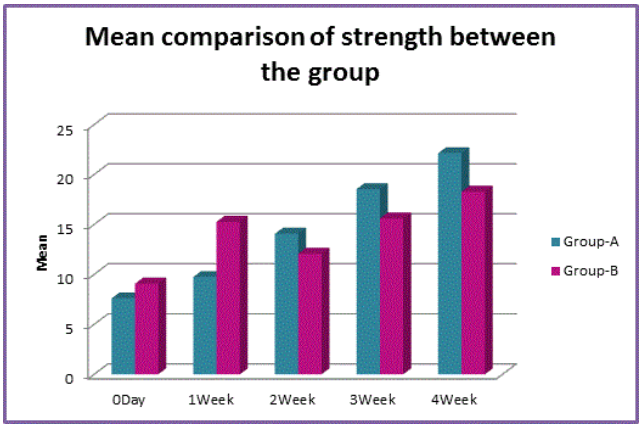
Table 2: ANOVA within group-A

	F value	p value
Flexibility	3.066	0.022
Strength	14.975	0
VO2max	21.198	0

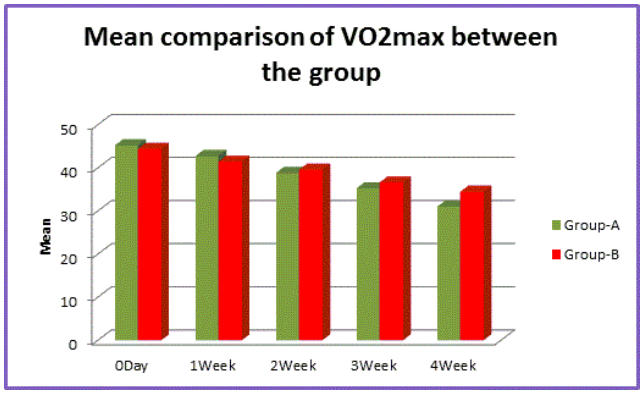
Table 3: ANOVA within group-B



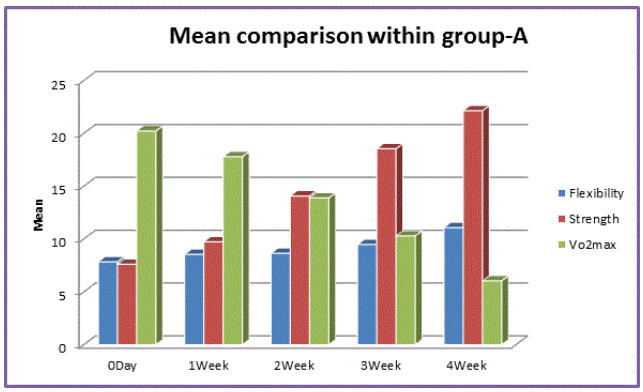
Graph 1: Mean comparison of flexibility within Group A and Group B at 0 day, 1st week, 2nd week, 3rd week and 4th week.



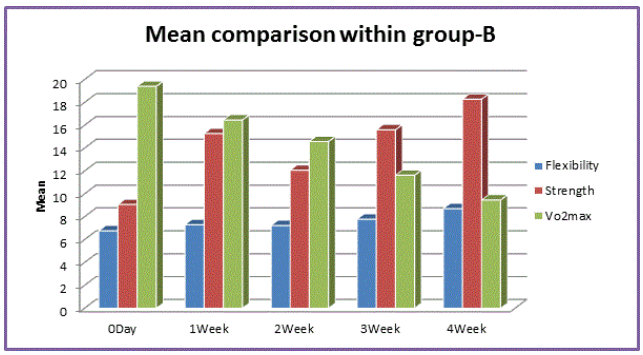
Graph 2: Mean comparison of strength within Group A and Group B at 0 day, 1st week, 2nd week, 3rd week and 4th week.



Graph 3: Mean comparison of VO within Group A and Group B at 0 day, 1st week, 2nd week, 3rd week and 4th week.



Graph 4: Mean comparison of flexibility, strength and VO_{2max} within Group A at 0 day, 1st week, 2nd week, 3rd week and 4th week.



Graph 5: Mean comparison of flexibility, strength and VO_{2max} within Group B at 0 day, 1st week, 2nd week, 3rd week and 4th week.

Discussion

The study aimed to find the effect of core strengthening on cardiovascular fitness, flexibility and strength on patients with low back pain. The benefits of core strengthening are profound and it also improves cardiovascular fitness, muscular strength, flexibility and endurance. Studies have shown that patients with chronic LBP have reduced strength and greater atrophy of the back muscles in comparison with healthy control patients. Thus the study was designed to find the effect of core strengthening on cardiovascular fitness, strength and flexibility on patients with low back pain. The data analysis revealed that both the groups showed significant improvement in VO_{2max}, flexibility and strength ($p<0.05$) within the group.

According to (Susan C. Soroskys et al.) [1] "Cardiovascular training can enhance metabolism of free fatty acid thus reduces body fat, increases insulin sensitivity and improves blood flow to muscles, the involuntary cardiac muscles present in the heart facilitate the pumping of blood through the body. With regular exercise cardiac output increases, thus VO_{2max} increases. Heart rate lowers for a given level of exertion, and reduces blood lactate accumulation at a given sub-maximal level of exertion". (Stanley P. Brown) [14] Stated that with strengthening exercise, there is an immediate need to meet the increased demand of oxygen with an adequate supply. To do this, there is an integrated response from the cardiovascular and pulmonary systems. The heart rate and the strength of the cardiac contractions increase which produces a greater cardiac stroke volume. These factors result in an increase in the delivery of blood to the working muscles and this constitute the central factor for the increase in oxygen consumption that occurs with exercise. Both cardiac output and oxygen consumption increases step-by-step. The increase in oxygen consumption with exercise results from an increase in pulmonary ventilation. Pulmonary ventilation is the bulk of air into and out of the lungs. After the initiation of exercise, both the rate and depth of breathing increases, this results in an increase in pulmonary ventilation. As the intensity of exercise increases during activity more oxygen is extracted from the blood as the blood passes through the capillaries of the working muscles and more air is passed in and out of the lungs. The increased rate at which the lungs are ventilated allows more oxygen to be delivered to the working muscles.

Core strengthening exercise enhances flexibility of patients having low back pain. The exercises aim to correct muscle tightness, and allow the patient to assume a neutral position so that strength can be developed to help maintain correct neutral positioning during both static and dynamic conditions. Due to eccentric muscle contraction there is an overall increase in muscle length. The core muscles are the voluntary skeletal muscles and each individual muscle cell is called muscle fiber. During core strengthening exercises each muscle fiber extends to the full length of the muscle. According to (Susan C. Soroskys et al.) [1] "Flexion during the exercises may reduce facet joint compressive forces and provide stretch to the lumbar muscles, ligaments, and myofascial structures." (Gross and Worrell) [15] Emphasized on the importance of flexibility enhancement and reported that enhanced flexibility has a greater effect on the range of motion and decreases the risk of musculoskeletal injuries.

Core strengthening exercises enhanced the muscular strength on the patients having low back pain. Strength of core muscles is found to be affected in the patients with LBP. Studies have shown that patients with chronic LBP have decreased strength and greater atrophy of the back muscles and most commonly multifidi muscles are found to be

atrophied. According to (Faigenbaum AD) [16] "Strength training has been shown to have a beneficial effect on several health indices, such as cardiovascular fitness, body composition, bone mineral density, blood lipid profiles, and mental health". According to (Susan C. Soroskys et al.) [1] "The goal of a core strengthening program for low back pain is to correct muscle weaknesses and imbalances with strengthening exercises. Strength training has been used as a successful strategy to reduce LBP and improve function." "The strength training focuses on the abdominal and erector spine muscles which has an influence on biomechanical functions and stability of the spine and pelvis." Resistance exercises stress the body's musculoskeletal system, which enlarges muscle fiber and improves neural control of muscle function which results in greater muscular strength. Strength training increases the size and number of myofibrils, resulting in larger individual muscle fibers. McGraw stated that "Core exercises increases the muscle mass, strength of tendons, ligaments, and bone. It increases utilization of motor units during muscle contractions, thus increases the size and strength of fast-twitch muscle fibers from a high-resistance program and size of slow-twitch muscle fibers from a high-repetition program. It also increases blood supply to muscles (from a high-repetition program) and improved blood vessel health. It improves the coordination of motor units and increases the storage of fuel in muscles and also enhances the muscle endurance. According to (Janet Hopson et al.) "The strength of a muscle contraction depends upon the intensity of the nervous system stimulus, the number and size of motor units activated, and the types of muscle fibers that are stimulated." When we start a resistance-training program, there is a gain in muscular strength before any increase in muscle size. This is because internal physiological adaptations to training take place before muscle enlargement. The strength of a muscular contraction depends mainly on effective recruitment of the motor units needed for the contraction. The better the body gets recruited the stronger the muscles will be. In the first few weeks of a resistance-training program, most of the adaptation involves an increased ability to recruit motor units, which causes more muscle fibers to contract. In response to resistance training the neural activation improves and as a result to this the amount of actin and myosin within the muscle fibers increases. This leads to an increase in the size or cross-sectional area of the protein filaments and the size of slow- and fast-twitch muscles, thus greater increase in strength will result from hypertrophic changes in fast-twitch muscle fibers.

Core strengthening exercise has a significant result on flexibility on patients having low back pain. Muscles prone to tightness in LBP patients include erector spinae, quadratouslumborum etc., therefore the goal of a rehabilitation program for LBP is to correct muscle weakness and imbalances with strengthening exercises. The exercises aim to correct muscle tightness, and allow the patient to assume a neutral position so that strength can be developed to help maintain correct neutral positioning during both static and dynamic conditions. Additionally, it helps to improve posture and can reduce associated back pains and further injuries, improves muscle coordination and reduces muscle soreness [1]. The core muscles are the voluntary skeletal muscles and each individual muscle cell is called muscle fiber. During core strengthening exercises each muscle fibre extends to the full length of the muscle. Due to eccentric muscle contraction there is an overall increase in muscle length [2]. According to Susan C. Soroskys "Flexion during the exercises may reduce facet joint compressive forces and provide stretch to the lumbar muscles, ligaments, and myofascial structures." Gross and Worrell [16] emphasized on the importance of flexibility enhancement and reported that enhanced flexibility has a greater effect on the range of motion and decreases the risk of musculoskeletal injuries.

Conclusion

Core strengthening exercise improves muscle imbalances, posture and enhances cardiovascular fitness, flexibility and strength in patients with low back pain.

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