FLEX CEUs

Low Back Pain: Ideas for Exercise

Chronic Low Back Pain - The Exercise Prescription

Abstract

Chronic low back pain is a potentially disabling comorbidity of the obesity epidemic. Defined as pain in the lumbar region lasting more than three months, it can occur secondary to acute occupational, recreational or sports injury or as the result of cumulative trauma from occupational repetitive strain.

CLBP may be aggravated by occupational demands that promote poor posture and load the lumbar intervertebral discs - from heavy labor to extended sitting and standing.

The accumulation of adipose tissue in the central abdominal region further loads the lumbosacral spine contributing to malalignments and chronic pain.

Exercise has been proven to be a safe and effective first line intervention in the treatment, rehabilitation and prevention of CLBP. Exercise can promote fat burning.

Evidence based research using performance outcome measures, electromyography and ultrasound imaging is reviewed.

A deficit in strength of core musculature has been proposed as contributing to CLBP. Core strengthening and hypertrophy of key muscle groups can be achieved using an array of modalities including isometric exercise, stability balls and the Pilates method.

Keywords: Exercise prescription; Exercise testing; Exercise frequency; Exercise intensity; Stability balls; Core strengthening; Pilates method; American College of sports medicine; Obesity; Chronic low back pain

Mini Review

In 1996 the Department of Health and Human Services, responding to the alarming increase in prevalence of obesity in America, urged the Centers for Disease Control, the National Institutes of Health and the American College of Sports Medicine to establish evidence based guidelines for the level of exercise and physical activity needed to produce measurable results in normalizing body composition and mitigating the health effects of obesity [1,2].

Chronic low back pain (CLBP) is a potentially disabling comorbidity of the obesity epidemic. Defined as pain lasting more than three months, it can be aggravated by occupational demands that promote poor posture and load the lumbar intervertebral discs - from heavy labor to extended sitting and standing.

The American Council on Exercise (ACE) published the Clinical Exercise Specialist Manual in 1999. It recognized exercise as a first line intervention for those with CLBP and cites early research showing the frequency and severity of CLBP episodes were decreased in those who exhibited "good cardiovascular fitness, strong abdominal musculature and good paravertebral strength" [2].

The American College of Sports Medicine pioneered exercise programming for CLBP calling for resistance training to increase abdominal and lumbar extensor strength [3].

Experts agree caloric restriction combined with physical activity exceeding caloric intake remains the fundamental formula for optimizing body composition. Weight loss can be the single most effective intervention in mitigating the severity of CLBP for those who are obese [4].

The Bureau of Labor Statistics predicts the Fitness Industry will experience 30% growth by 2018. It's growing demand warrants higher standards of certification and licensure for fitness professionals working in traditional medical settings [5,6].

A perceived lack of standardization in screening, dose assignment and assessment of safety, efficacy and outcome measurements for exercise programs designed to rehabilitate CLBP, hinders their acceptance and inclusion in traditional medical settings.

CLBP drives emergency room, urgent care and primary care office vists and accounts for fully one third of Workers Compensation costs. While the majority of low back pain episodes subside within three months of onset, recurrence rates as high as 60% have been reported [3].

An extensive body of research exists proving selected exercises to be a first line intervention in the prevention, treatment and rehabilitation of CLBP [7-11].

The Association of Chartered Physiotherapists published Therapeutic Exercise for Lumbopelvic Stabilization in 2004. It offers evidence based practical guidance on key muscle systems involved in the prevention and rehabilitation of CLBP.

Core muscles strengthen and stabilize the spine, pelvis and shoulders. They include Rectus Abdominis, Erector Spinae, Multifidus, External and Internal Obliques, Transversus Abdominis, Hip Flexors, Gluteus Maximus, Medius and Minimus, Hamstrings, Hip adductors and Piriformis [11].

Peer reviewed research studies document improvement in CLBP using performance outcome measuerments for core strengthening exercises. Performance standardization is achieved through evidence based science using electromyography (EMG). EMG research detects patterns of core muscle activity in patients with CLBP [12,13].

Individuals with CLBP have been found to exhibit greater trunk muscle activity and observed "stiffness" during exercises in the frontal, saggital and transverse planes. These findings have been interpreted as being due to muscular spasm [13].

Hodges et al. cite "ineffective muscular stabilization of the lumbar spine" in those with CLBP using EMG research focused on motor control of a principle muscle in core strength and stability - Transversus Abdominis [14].

Defiencies in EMG activity in Multifidus and the Iliocostalis Lumborum muscles were detected when comparing healthy controls with patients with CLBP by Danneels et al. [15].

Researchers from the University of Autralia's Department of Sport and Exercise Science recorded lumbar spine range of motion and corresponding EMG activity in those with CLBP performing commonly recommended core strengthening and stabilizing exercises. Muscle activity was measured using pairs of surface electrodes from Rectus Abdominus, External obliques and Lumbar Erector spinae [13].

The researchers detected no increase in trunk muscle activity or stiffness when comparing CLBP patients with healthy controls. Of significance, they documented no worsening of CLBP during performance of commonly recommended core strengthening exercises [13].

A highly referenced study on EMG activity of lumbar muscles during isometric exercise in those with CLBP was conducted by a multidisciplinary team of exercise physiologist, physical therapists and physicians. Cassisi et al. studied core and lumbar paraspinal muscle activity across five angles of flexion during isometric exercises and at rest in health controls and those with CLBP [12].

The group used surface integrated EMG to determine whether CLBP subjects exhibit a high muscle tension spasm model versus a low muscle tension deficiency model. Their conclusions support the model of CLBP as a muscular deficiency state.

Thus, EMG research supports the safe and effective role core strengthening exercise plays in the Exercise Prescription for CLBP. A systematic review on the effectiveness of physical and rehabilitation interventions for CLBP found that compared to usual care, "exercise therapy improved post treatment pain intensity and disability [16].

One of the most well researched interventions for CLBP is the Pilates method. Joseph Hubertus Pilates emigrated to the US in 1923 to establish a vanguard New York studio in which he applied his "Contrology" method to the rehabilitation of professional dancers. Torso stability acchieved through abdominal strength is a governing concepts of the Pilates Method [17].

EMG analysis of both Pilates mat, reformer and Cadillac trapeze demonstrate increases in joint flexibiiity, muscle strength, balance, stabilization and whole body conditioning in those with CLBP [18].

Both Pilates and core strengthening exercise produced clinical improvement in a randomized study of 87 volunteers with CLBP. Significant improvement on self reported measures of pain, disability and function were documented with both interventions [19].

Researchers from the University of Portugal analyzed EMG activity of the Transversus Abdominis, obliques and Multifidus during Pilates exercise. They conclude, "The Pilates Method develops strength of the body center, focusing on the contraction of muscles and contributing to lumbosacral stability" [20].

Measurements with ultrasound screening of Transversus Abdominis and Obliques activity during Pilates exercise showed measurable increased thickness of the muscle groups [21].

The Mayo Clinic has developed an online slide show of exercises proven effective in core strength and stabilization [22].

The National Strength and Conditioning Association (NSCA) offers an on-line Webinar produced by Nick Tumminelos NSCA-CPT, titled Top Ten Abdominal Exercises grounded in evidence based science. Top exercises involve the use of a stability ball including the Pike and Rollout [23].

Sawyer Enterprises produces Progressive Exercise Prescription Pads (PEP Pads) for back strengthening and lumbosacral stretch, designed to improve strength, endurance, mobility and flexibility of the spine. PEP Pads can be used to complement traditional therapies for CLBP. Each PEP pad offers individualized recommendations for exercise frequency, repetitions, precautions as well as progress and outcome notes [24].

The American College of Sports Medicine was founded in 1954 as the world's largest sports medicine and exercise science organization. Called the "Gold Standard" in exercise science, ACSM's Guidelines for Exercise Testing and Prescriptions offers evidence based standards for exercise testing and prescription (Figure 1).

Figure 1: The Pike is ranked the number one exercise for ab strengthening by Nick Tumminelo [23].

The 9th edition offers the latest in research and clinical science and summarizes key components of the exercise prescription for CLBP including exercise methods, frequency, intensity and duration [25]. Exercise programming includes progression in core and extremity strength, postural stabilization [26] and muscular enduranceto meet both occupational and functional demands (Figures 2 to 10).

Figure 2: The Mayo Clinic recommends the Superman for core strengthening [22].

Figure 3: The Pilates Cadillac Trapeze reformer can be used to create modified "bridge" exercises to lift and strengthen the pelvis and lumbosacral spine. From the practice of Ahimsa Porter Sumchai MD, NSCA-CPT.

Figure 4: The Pilates ring serves as a rigid suspension prop to strengthen and lengthen the spine. From the practice of Ahimsa Porter Sumchai MD, NSCA-CPT.

Figure 5a: The Rainbow is ranked one of the top 10 ab strengthening exercises by Nick Tumminelo [23].

Figure 5b: Barbell tight rotations.

Figure 5c: Barbell tight rotations - completion.

Figure 6: The deadlift has been shown to strengthen the "kinetic chain" muscles of the posterior compartment including Lumbar Erector Spinae, Gluteus Maximus and Minimus, Hamstrings and Calf muscles [23].

Figure 7: The rollout on a stability ball is ranked a top exercise for ab strengthening by Nick Tumminelo [23].

Figure 8: A modified plank on a stability ball anchored by a barbell and power rack. From the practice of Ahimsa Porter Sumchai, MD NSCA-CPT.

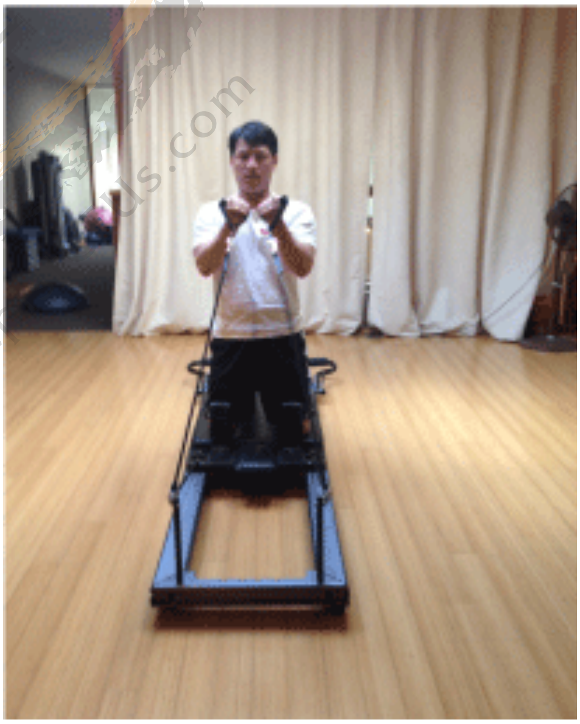


Figure 9a: Exercises performed in the kneeling position on the Pilates Allegro Reformer rigorously engage the core in strength, balance and stabilization [17].

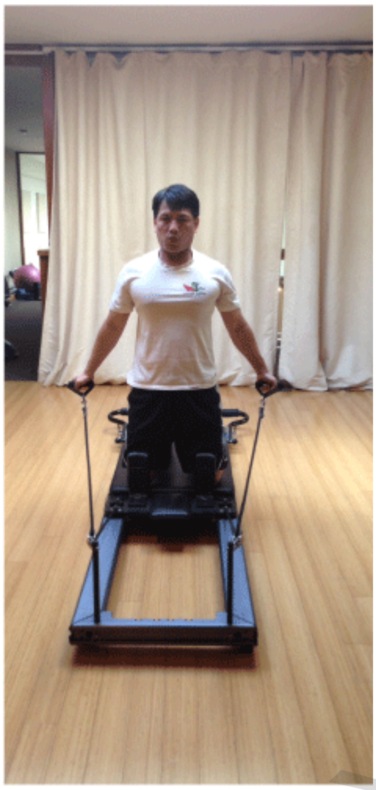


Figure 9b: Kneeling on the Pilates reformer.

Figure 10: Research suggests exercises that involve motion of the pectoral girdle and shoulder girdle maximally engage the core [23].

Effects of a Twelve-Week Program of Lumbar-Stabilization Exercises on Multifidus Muscles, Isokinetic Peak Torque and Pain for Women with Chronic Low Back Pain

Abstract

Objective: This study aim was to evaluate the effects of the lumbar stabilization exercises on cross-sectional area (CSA) of the multifidus muscle, trunk muscles' isokinetic peak torque, pain and disability in women with chronic low back pain (cLBP).

Methods: The experimental group (EG; n=55) was enrolled in a 12-week lumbar stabilization exercises program. Control group (CG; n=51) did not undertake exercises. Before starting the exercise program, after completing it and 1 and 2 months after the intervention the following tests were carried out: isokinetic peak torque at an angular velocity of 60 deg/s was measured using a isokinetic dynamometer; measurement of the CSA of the multifidus muscle was performed using a ultrasound system, and patients were assessed using the Oswestry Disability Index (ODI), as well as visual analogue pain (VAS) rating scales.

Results: After intervention, isokinetic peak torque (41.25% extension and 21.53% flexion) and multifidus muscle CSA (right side: 37.41 ± 0,7%; left side: 37.53 ± 0.7%) increased, VAS (44.00%) and ODI (48.74%) decreased.

Conclusion: After 12-week lumbar stabilization exercises program, multifidus muscle CSA and trunk muscles peak torque increased, disability and cLBP decreased, and these changes lasted for 2 months.

Keywords: Lumbar stabilization exercise; Chronic low back pain; Isokinetic trunk flexion and extension

Introduction

Chronic low back pain (cLBP) is one of the most prevalent musculoskeletal disorders and it enhances the economic burden [1]. Over the last decade, a number of studies have reported dysfunction of voluntary activation of multifidus and abdominal muscles in connection with recurrent or cLBP [2-4]. Patients with cLBP show reduced endurance and strength of the muscles of the lumbar and hip, and decreased flexibility of the back as a result of prolonged anomalous posture, which may account for the pain [5]. A common variation is a delay in activation of the deep muscles (transversus abdominis, obliquus internus abdominus) only during rapid voluntary limb movements [6,7].

There is evidence that patients with cLBP have a smaller cross-sectional area (CSA) of the multifidus muscles compared to healthy volunteers [8-11]. The multifidus muscles act as lumbar stabilizers and control the intersegment motion of individual vertebrae [12]. Ultrasound imaging has been proved as a non-invasive method to take the measurements of the activation of selected muscles [13]. Using ultrasound imaging and magnetic resonance imaging for a research of healthy young females showed that the multifidus muscles are symmetrical on either side of each vertebral level studied (L2-S1) and grew in size from L2 to L5 [14]. A systematic review by Fortin and Macedo showed that patients with cLBP have smaller multifidus and paraspinal muscle groups than healthy subjects [12]. Dysfunction of the lumbar multifidus muscles is closely associated with cLBP as it is likely to be due to pain inhibition from the spine [15]. Perhaps future studies will determine whether muscle atrophy is a cause or a result of cLBP [12].

The stability of the lumbar spinal segments is an important component of the biomechanics of the body, a deficiency of which can affect the occurrence of cLBP [16]. Hides et al. measured the response to an abdominal drawing-in task of CSA of the waist, the thickness of the internal oblique and transversus abdominis muscles and the shortening of the transversus abdominis muscle and found changes in the measurements between the beginning and the finish of a 13-week cricket training camp [10]. In this research the subjects made 13-week practice of individual skills, gym sessions and weight training. Participants from the group with cLBP experienced with a 6-week stabilization training program which included performing voluntary contractions of the multifidus, pelvic floor and transversus abdominis muscles while obtaining feedback from ultrasound imaging. The motor control of cricketers with cLBP who obtained the stabilization training improved and was similar to that of the cricketers without cLBP in the end of the training.

Stuge et al. established that a group who performed specific stabilizing exercises (20 weeks) showed statistically and clinically lower pain intensity, lower disability, and higher quality of life contrast to a control group (group received individualized physical therapy without specific stabilizing exercises), after intervention and at one-year post-partum [17]. While changes were negligible in the control group, disability was reduced by more than 50% in the exercise group.

Smith et al. study indicated that lumbar extension training with pelvic stabilization can be an effective treatment for cLBP, however lumbar extension training without pelvic stabilization did not increase lumbar muscle strength. Stabilization of the lumbar spine significantly increases back extensor muscle strength, reduces soreness and improves outcomes as measured by the Oswestry Disability Index (ODI) [18]. These results show that the lumbar stabilization exercise program is effective for the treatment of cLBP with the aim of preventing the recurrence of symptoms [19]. It is therefore important to assess the lasting impact of exercise programs on the treatment of cLBP. The lumbar stabilization exercises have been designed in order to enhance the neuromuscular control system and correct the dysfunction [20]. The Pilates method can be used as an adjunctive lumbar stability exercise program to improve flexibility and enhance control of trunk and pelvic segments and core stability [21].

The main aim of this study was to evaluate the effects of a program of lumbar stability exercises on multifidus muscles in parallel on both sides of the spine in the L4-L5 region, isokinetic peak torque of flexor and extensor of trunk muscles, pain and functional condition in women with cLBP. We also assessed changes in trunk muscle size and strength up to 2 months after completing a 12-week training program.

We hypothesize a 12-week lumbar stabilization program for women with cLBP will decrease and this effect will persist after two months.

Materials and Methods

One hundred-six female volunteers suffering non-specific cLBP were divided randomly from an experimental group (EG; n=55) and a control group (CG; n=51). All subjects had been suffering from cLBP for at least 3 months. The study did not include patients with neurological symptoms, spinal damage, cancer or infectious diseases that could lead to cLBP, and other diseases that could affect physical performance. Those who had paresthesia, myoparalysis, or psychological problems as well as those who had difficulty in performing exercise due to lack of comprehension were also excluded. None of the study participants had undergone surgery for cLBP. Participants in the CG and EG groups had not performed lumbar stabilization exercises before. The mean age of the EG subjects was 53.3 ± 5.3 years, their body weight was 68.1 ± 8.9 kg, height 166.4 ± 2.8 cm. The CG included women aged 51.5 ± 7.4 years, with a body weight of 65.1 ± 6.4 kg, and a height of 167.5 ± 1.9 cm. The EG subjects were enrolled in a 12-week exercise program to increase lumbar stability. None of the women had previously been involved in similar studies. All subjects were asked not to use any medication, such as muscle relaxants, analgesics, and psychotropic drugs, for at least 4 days before testing.

Inclusion criteria of EG are as follows:

- cLBP persisting for more than 3 months in the absence of an underlying pathology
- Aged between 51 and 58 years
- Pain between 3 and 6 at rest on a 0- to 10-point pain visual analog scale (VAS), where 0 represents no pain and 10 is the worse pain imaginable
- No contraindication for exercise
- No obvious deformity of the spine, pelvis, and lower extremities
- No autoimmune diseases (e.g., rheumatoid arthritis)
- No pregnancy

CG women did not undertake lumbar stabilization exercises program. This study was approved by Regional Biomedical Research Ethics Committee. Each volunteer read and signed the informed consent form before participation in the study.

Before starting the lumbar stabilization exercise program, after completing it and 1 and 2 months after the intervention the following tests were carried out: isokinetic peak torque at an angular velocity of 60 deg/s was measured using a Biodex System 3 Pro isokinetic dynamometer; measurement of the cross-sectional area of the multifidus muscle was performed using a TITAN™ ultrasound system, and patients were assessed using the ODI, as well as VAS rating scales.

Lumbar stabilization exercises were performed twice per week; the duration of each session was 45 minutes. The program lasted for 12 weeks, thus patients underwent a total of 24 exercise sessions. Exercise program consisted from stretching, pelvic tilt, flexion and extension strengthening of the abdomen and the trunk muscles. The subjects conducted the lumbar stabilization exercise program for 45 minutes. This program is divided into 3 categories: warm up, main part and cool down [22]. The EG participants were required to perform from 4 to 16 repetitions some of exercise. The physiotherapist controlled the subject's lumbar neutral spine position at the start of each exercise, and the subjects were asked to keep this position through the exercise. The exercises were performed in a same order. Markers were placed on the floor to standardize the position of the subject and the equipment. The exercises met suggested criteria for safety; these included the avoidance of active hip flexion with fixed feet positioning and pulling with the hands behind the head and ensuring knee and hip flexion during all upper body exercises (Figures 1A-1N).

The subjects were tested using a Biodex Medical System PRO 3 dynamometer (certified ISO 9001 EN 46001; Shirley, NY, USA). Isokinetic peak torque was measured at an angular velocity of 60 deg/s [23,24]. Mechanical brakes were applied at 60° of amplitude in order to minimize unwanted movements [25]. Prior to testing, all subjects were familiarized with the methodology of the assessment and then performed a standard warm-up which involved exercising on the ergometer (Ergo-Fit Ergo Cycle 177, Germany) at low intensity for 5 minutes (heart rate 110-130 beats/min). After warming up, the subjects sat in the Biodex System 3 PRO chair (Figure 2) and remained quiet for 2 minutes. Shoulder, torso and thigh straps were used to maintain the angle between the waist and thigh at 90° [23]. During the test the subjects were asked to minimize head movements and keep hands crossed on the chest. After several practice movements followed by 5 min rest, volunteers performed maximal isokinetic voluntary trunk flexion involving three trunk flexion and extension movements using maximal effort. For data analysis we used the value indicating the highest maximal force.

Ultrasound scanning of the muscles was carried out using a TITAN™ ultrasound system (SonoSite Inc., Bothell, WA, USA). Multifidus muscle CSAs (cm^2) were measured in the B-scan mode. An HST/10-5 MHz 25 mm linear probe was used to image the surfaces of the muscles, organs and blood vessels, at a frequency of 10 MHz. During the study, subjects were positioned face down in a relaxed, neutral head position, with their arms relaxed at their sides. A small pillow was placed under the abdomen to reduce lordosis of the lumbar spine. Ultrasound scanning of multifidus muscles was performed in parallel on both sides of the spine in the L4–L5 region (Figure 3). The fourth lumbar vertebra (L4) was identified by palpation, starting from the wings of the hip bones towards the centre line [22,26].

The ODI questionnaire was used to evaluate the influence of cLBP

Hundreds: Lie flat on the mat with your legs together. Exhale as you curl your head and shoulders up, lift and hover your arms off the mat, and raise both legs off the mat to the desired height. Begin to pump your arms (100 times). Inhale for five arm pumps and exhale for five arm pumps. Keep the abdominals drawn into the mat and your back flat and stable on the mat.

Rolling: like a ball: In a seated position, hug your shins into your chest and balance on your sacrum to lift your feet off the mat and hold your body in a ball shape. Your knees remain shoulder distance apart with the ankles close together. Inhale as you roll back to your shoulder blades, exhale and roll up to the start position, maintaining the curve of the spine. Maintain the C-curve shape of your spine, while continuing to pull the abdominals into the spine, and roll evenly down the middle of the spine. Your head and neck should not touch the mat as you roll back to perform 8 repetitions.

Curl Ups: Starting position is neutral spine and pelvis, inhale, with exhaling curl spine, keeping head in the palms and space between chin and chest, legs in one line with hips, or in frog position, inhale, with exhaling lay down to the starting position to perform 16 repetitions.

Knee rolls: Position of legs slightly wider than hip-width apart, breath in preparing body to move, breath out rolling left leg in from the hip joint and simultaneously roll the right leg out, from the hip joint. Both knees will therefore roll to the right and the head to the opposite side. Breathe out and return both legs back to the center at the same time. Repeated to the other side to perform 8 repetitions in both sides.

Single leg stretch: Starting position is neutral spine and pelvis, double knee fold one leg at a time with stability, connect inner tights and softy point the feet. Breath in preparing body to move, and as breath out curl up and place arms on the outside of the shins. Breathe out as lowering right leg, simultaneously placing the right hand on the left knee, and left hand to the left shinbone. Repeat on the other leg to perform 8 repetitions.

Side balance: Lie on the right side and correctly align pelvis and spine in neutral keeping head, neck and legs in line with spine, connecting inner tights in parallel with softly pointed feet. Breathe in to prepare breath out then lift both legs from the mat to the level with the top of the pelvis and stay keeping them maintaining a stable and still pelvis and spine for the 10-20 sec. Repeated to the other side.

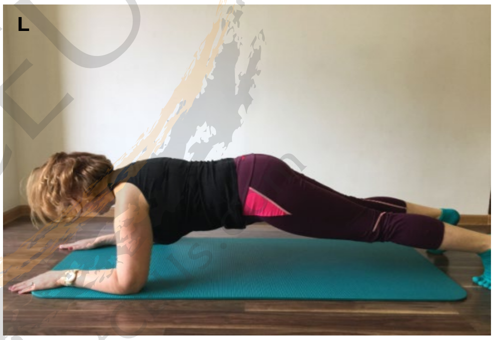
Side band with rotation and opening the leg to the oyster: The starting position is on the left side with hip, knee and elbow in a line, keeping both legs together with inner tights connected. Breathe in and maintaining a neutral pelvic and the scapular stable open top knee and arm, keeping feet connected together, breathe out and rotate the spine to the mat, simultaneously reach with left arm the floor under the right side. Repeated to the other side and to perform 8 repetitions in both sides.

The cat: The starting position is four point kneeling, breath in to prepare the body to move, with breath out roll the pelvic underneath, flex and round the lower back, continue this flexion to allow upper back to round gradually followed by the neck to perform 4 repetitions.

Table top: The starting position is four point kneeling. Breathe in to prepare and lengthen the spine. Breathe out, maintaining a still and stable pelvis and spine, slide one leg behind, directly in line with the hip and lift the leg to hip height. Simultaneously raise the opposite arm forward, to the shoulder height. Repeated to the other side and to perform 8 repetitions in both sides.

Freeding like a needle: The starting position is four point kneeling. Inhale to prepare. Breathe out and rotate the spine in the same time sliding with the right arm to the left side, in the same time bend the left arm, keeping the scapular stable, and pelvis in neutral. Repeated to the other side and to perform 4 repetitions in both sides.

The Dart: Starting position lying on the front, correctly aligning the pelvic and spine in neutral, rest the forehead on a small cushion and lengthen arms by the side of the body on the mat, the palms are facing the ceiling, and the legs are straight. Inhale in preparing and breathe out then lift first head, then neck, then chest and upper spine of the mat. Breathe in and hold this lengthened and stable position, breath out then return the spine to the starting position.



Plank prone position: Keep neutral position of the spine and pelvis, touching the floor with elbows and toes and breathe deeply with deep breath in and breathe out. Stay in this position from 10-20 s. At the beginning of the program, is kept for 10 s, when the core stability muscles become stronger, the 20 s is applied.

Plank side position: Keep neutral position of the spine and pelvis on left side, touching the floor with elbow and knee and breathe deeply with deep breath in and breathe out. Stay in this position from 10-20 sec and change other side. Repeated to the other side and to perform 8 repetitions in both sides. At the beginning of the program, is kept for 10 s, when the core stability muscles become stronger, the 20 s is applied.

Spine curl: Starting position- the relaxation position with neutral pelvis and spine, breath in to prepare breath out and curl the pelvis from the mat sequentially up from the mat vertebra by vertebra rolling the spine. Breathe out as roll the spine back to the neutral position.

Figure 1: Lumbar stabilization exercise program.

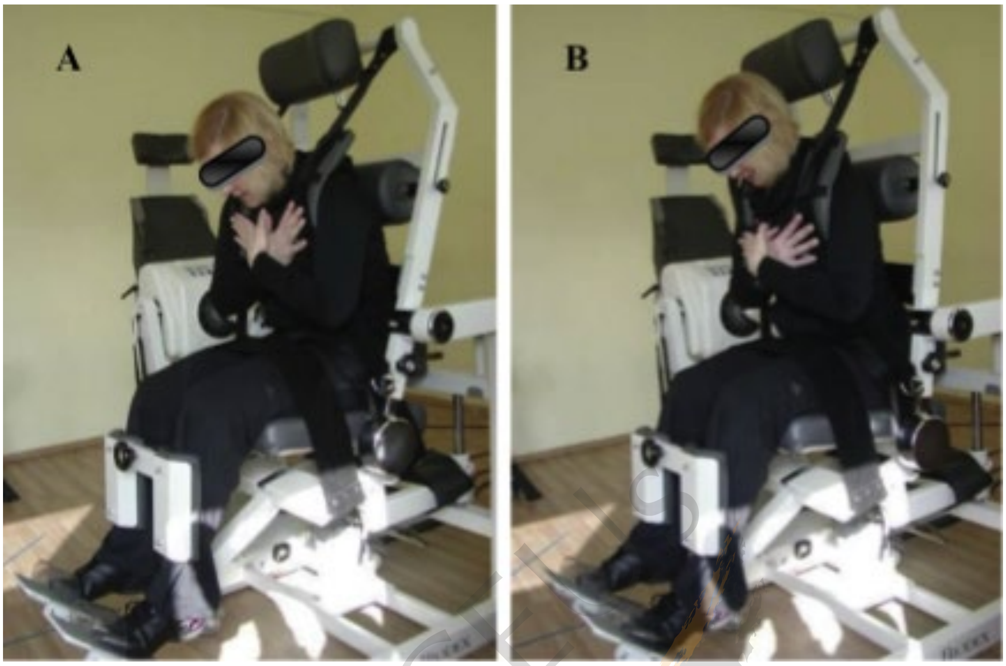


Figure 2: Isokinetic trunk flexion (A) and extesion (B) mode [21].

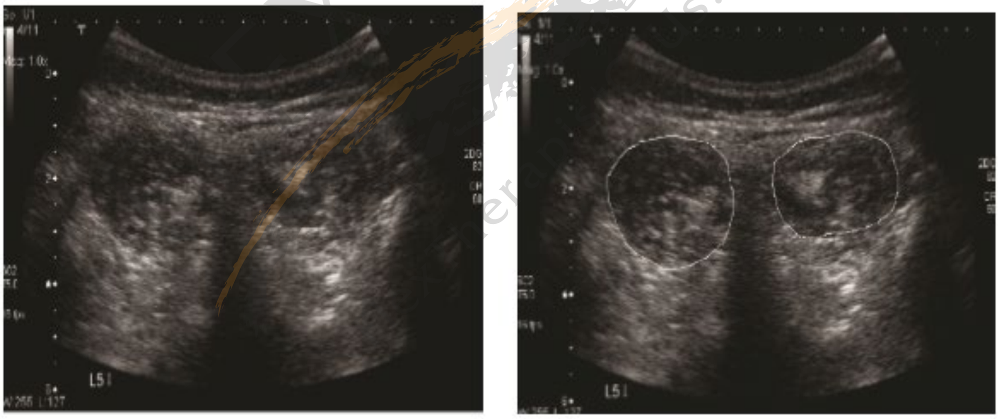


Figure 3: Bilateral transverse image at the L5 vertebral level showing atrophy of the right lumbar multifidus muscle, with and without CSA tracings [19].

intensity on the patient's functional state in different life situations. The ODI questionnaire was used to evaluate the influence of cLBP intensity on the patient's functional state in different life situations [27]. Pain intensity was evaluated using a visual analogue pain scale (VAS) with a range of 0 to 10 points, where 0=no pain; 2=mild pain; 4=moderate pain; 6=severe pain; 8=very severe pain; and 10=unbearable pain [28,29].

The data were tested for normal distribution using the Shapiro-Wilk test, and all data were found to be normally distributed. A two-way mixed analysis ANOVA (General Linear Model) was used to determine the effect of the lumbar stabilization exercise program as within subject factor of two levels in group and between groups (CG and EG). A significant result was followed by LSD post hoc adjustment to determine differences between the lumbar stabilization exercise-training conditions. If Mauchly's Test of Sphericity was significant then the Greenhouse-Geisser correction was used. The level of significance was set at $p<0.05$. The standard deviations and 95% confidence intervals are presented together with the mean values. All statistical analyses were performed using IBM SPSS Statistics 22 (IBM Corporation, Armonk, NY).

Result

At the start of the study maximal isokinetic trunk extension and flexion peak torque did not differ between the EG and the CG ($p>0.05$). After completing the 12-week lumbar stabilization exercise program, trunk flexion (41.25 ± 9.25%) and extension (21.53 ± 4.48%) strength increased ($p<0.001$) in the EG. This increase in strength remained statistically significant after 1 month and 2 months post the lumbar stabilization exercise program. ($p<0.05$) (Table 1).

	Baseline		Post intervention		1mth post LSEP		2 mth post LSEP	
Group	**Extension**	**Flexion**	**Extension**	**Flexion**	**Extension**	**Flexion**	**Extension**	**Flexion**
Experimental (N = 25)	153.42 ± 22.35	100.29 ± 22.24	216.70 ± 26.93*#	121.88 ± 20.22*#	194.93 ± 29.81*#	119.15 ± 19.63*#	168.46 ± 26.69*#	112.53 ± 15.01*#
Control (N=11)	137.64 ± 19.35	92.05 ± 18.91	140.15 ± 23.39	91.9 ± 16.55	132.78 ± 20.26	84.91 ± 15.88	131.75 ± 23.31	85.25 ± 13.42
(*-Difference from the initial Peak torque values, p<0.05; #-Difference peak torque between the experimental and the control groups, p<0.05) **(LSEP**-lumbar stabilization exercise program)								

Table 1: Values of maximal isokinetic trunk extension and flexion Peak Torque (Nm).

	Baseline		Post intervention		1mth post LSEP		2 mth post LSEP	
Group	**Right side**	**Left side**	**Right side**	**Left side**	**Right side**	**Left side**	**Right side**	**Left side**
Experimental (N = 25)	6.57 ± 0.7	6.55 ± 0.9	9.12 ± 0.9*#	9.38 ± 1.1£€	8.26 ± 0.6*#	8.41 ± 0.7£€	7.46 ± 0.6*#	7.53 ± 0.7£€
Control (N=11)	6.98 ± 1.2	7.04 ± 1.1	6.88 ± 1.2	6.99 ± 0.9	6.77 ± 0.8	6.78 ± 0.7	6.84 ± 0.8	6.87 ± 0.7
(*-Difference from the initial values CSA right side, £-Difference from the initial values SCA left side, p <0.05; #-Difference between the experimental and the control groups SCA right side, p<0.05, €-Difference between the experimental and the control groups CSA left side, p<0.05)								

Table 2: Values of cross-sectional area (cm^2) of lumbar multifidus muscles.

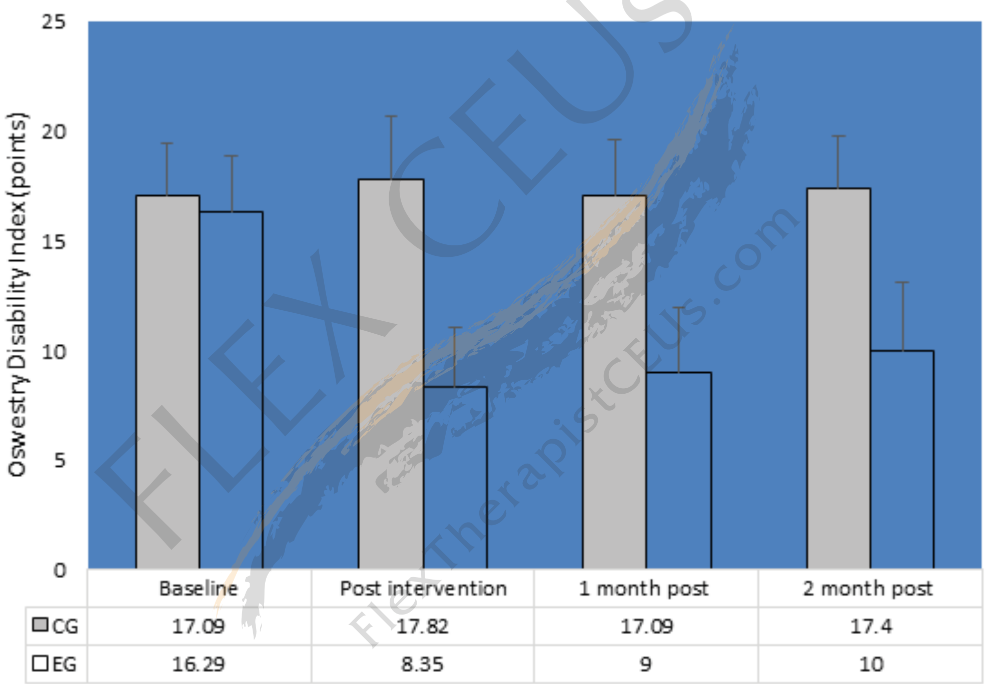


Figure 4: The Oswestry Disability Index baseline, post intervention, and 1 month and 2 months post the lumbar stabilization exercise program. (*Difference from the initial value, p<0.05; # difference between the experimental and the control groups, p<0.05).

The isokinetic trunk flexion muscles post intervention of the lumbar stabilization exercise program significantly depended on the isokinetic trunk flexion muscle endurance baseline the intervention (r=0.552, p<0.05). The results of isokinetic trunk flexion muscle endurance tests significantly depended on the trunk extension muscle endurance baseline the intervention, and at 1 month post LSEP (r=0.734, p<0.001) and 2 month post intervention (r=0.781, p<0.001).

Initially, there was no significant difference in the CSA of the multifidus muscle CSA between the EG and the CG, either on the right side or on the left side (p>0.05). At the end of the 12-week exercise training program, the multifidus muscle CSA values were significantly higher on both the right side (45.24 ± 1.2%) and the left side (44.81 ± 0.9%) in women in the EG (p<0.05). This increase in multifidus muscle's CSA was maintained after 1 month (right side: 39.45 ± 0.6%; left side: 40.12 ± 0.7%) (p<0.05) and 2 months (right side: 37.41 ± 0,7%; left side: 37.53 ± 0.7%) (p<0.05) (Table 2).

At the start of the study ODI scores did not differ (p>0.05) between the EG and CG groups. After completing the 12-week lumbar stabilization exercise program the ODI scores decreased by 48.74 ± 7.81% (p<0.05) in the EG, and this reduction persisted for 1 month and 2 months post the lumbar stabilization exercise program (Figure 4).

At the start of the study there was no significant difference in pain intensity between the EG and the CG (p>0.05). At the end of the 12-week exercise program, cLBP intensity decreased by 1.50 ± 0.3 (p<0.05) in the EG, and this reduction persisted for 1 month and 2 months post the lumbar stabilization exercise program (Figure 5).

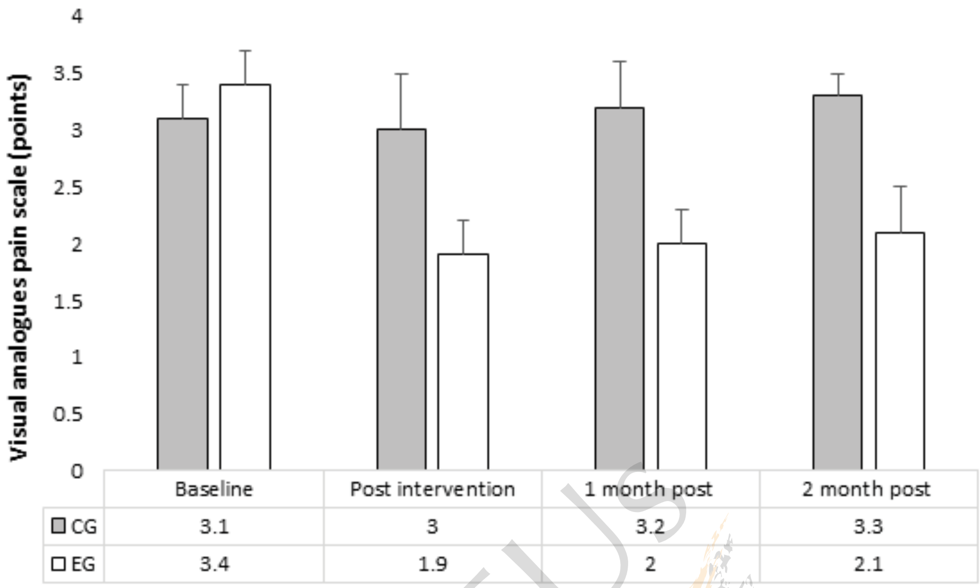


Figure 5: Chronic low back pain baseline, post intervention, and 1 month and 2 months post the lumbar stabilization exercise program. (*Difference from the initial value, $p < 0.05$; # difference between the experimental and the control groups, $p<0.05$).

Discussion

Our results show that the 12-week lumbar stabilization exercise program induces beneficial adaptations in women with cLBP. We found that multifidus muscle CSA and trunk muscle isokinetic peak torque increased while ODI decreased after this intervention, suggesting that lumbar stabilization exercises are effective in relieving cLBP. Previous studies have also shown that 4, 6, 10, 12, 16 or 20 weeks of the lumbar stabilization exercise program are effective for pain relief and improvement of trunk muscle function [17,18,22,23,30,31].

After completing the lumbar stabilization exercise program, back pain intensity and ODI decreased in the women in our study. Comparing the results obtained immediately after finishing the lumbar stabilization exercise program with the results after 2 months it was evident that without continuing lumbar stabilization exercises, the maximal isokinetic trunk flexion strength and maximal isokinetic trunk extension strength both decreased.

Our results showed a large increase in trunk muscle strength after completing the 12-week exercise program. It is likely that muscle strength was influenced by pain during initial measurements. Motor control might therefore change significantly as activity of the agonist muscles decreases while antagonist muscle activity increases to reduce speed, strength and amplitude of the movements in the presence of pain [6]. After lumbar stability exercise program on pain and active range of motion of trunk flexion increased significantly in the lumbar stability exercise group, but a significant increase was not found in the control group [31]. Gruther et al. considered that in chronic cLBP, dynamometric trunk muscle measures are limited to muscle functions evaluation purposes [32]. Goldby et al. applied a 10-week lumbar stabilization exercise program and collected data at baseline, and at 3, 6, 12, and 24 months after intervention [30]. Their results indicated statistically significant improvements in favour of the spinal stabilization group at the 6-month stage in pain (65.9% reduction in symptoms) and dysfunction, and at the 1-year stage in disability. In contrast, Unsgaard-Tøndel et al. found no significant group differences in pain, disability, trunk flexibility, or fear-avoidance beliefs after treatment 8 weeks of motor control exercises, sling exercises, and general exercises and at a 1-year follow-up in patients with chronic nonspecific cLBP [33]. In a recent scientific research was found that were no differences between lumbar stability exercise program and general exercises with regard to pain and functionality in nonspecific cLBP subjects, but general exercises were better than lumbar stability exercise program for increasing functionality and flexibility [34].

We found that the lumbar stabilization exercise program resulted in a significant increase in the cross-sectional area of the multifidus muscle CSA and strength of rectus abdominis and erector spine muscles for women in the EG and these increases were maintained for 2 months. The significant improvement in the ability to contract the transversus abdominis after a program of lumbar stabilization exercises concurs with the findings of Ferreira et al. [35]. In their study, 11 patients undertook stabilization exercise therapy, and a further 23 patients either performed general exercise or received spinal manipulation. Compared with the latter groups, the stabilization group showed significantly ($r=-0.35$; 95% CI 0.02 to 0.62) greater changes after intervention in the ability to recruit the transversus abdominis 7.8% than participants receiving general exercise 4.9% or spinal manipulative therapy 3.7%.

The pain intensity of cLBP in the women in the EG immediately after the intervention significantly correlated with maximal isokinetic trunk flexion strength and the ratio of isokinetic trunk extension and flexion strength. After 1 month without the lumbar stabilization exercise program, pain intensity significantly depended on the maximal isometric flexion strength. Gruther et al. established that among dynamometric tests, isokinetic measurements produced the best area under the curve for discriminating between patients with cLBP and healthy controls [32]. Above mentioned authors research showed that reliability testing revealed highly significant learning effects for isokinetic trunk flexion and isokinetic measurements. Sekendiz et al. found that stabilization program exercises were an efficient training method, producing a positive significant changes in abdominal and lower back strength, posterior trunk flexibility and abdominal muscular endurance in sedentary adult females [24]. The results showed a significant difference between pre- and post-exercise measurements with isokinetic dynamometer of abdominal and lower back peak torque at 60 deg/s flexion/extension and 120 deg/s flexion. The trunk muscle peak torque was measured at an angular velocity of 60 deg/s flexion/extension in our studies and also showed significant improvement after stabilization program exercises.

Our results demonstrate that 12 weeks of a lumbar stabilization exercise program involving 24 sessions carried out two times per week is effective in relieving cLBP and improving patients' function. Even after a month without exercise, muscle CSA and strength remained elevated compared to the initial measurements and the CG which did not perform exercise training. Nevertheless, the program did not result in the permanent reduction of cLBP, which returned to previous levels within 2 months. Stuge et al. showed that the effect of 20 weeks of a specific stabilization exercise program reduced pain and level of disability and increased quality of life (ODI) compared to an exercise program without stabilization exercises [17]. They found that this improvement remained even after a year of inactivity. The most important factors for the treatment of cLBP, ensuring improvements in the patients' functional state and maintaining its lasting effect are abdominal and back muscle static endurance, isometric abdominal muscle strength and similarity between trunk flexion and extension strength. The purpose of specific stabilization exercises is to improve the endurance and strength of muscles responsible for dynamic stabilization and neural-muscular control of the lumbar spine [10]. We found that, at 1 and 2 months after ending the lumbar stabilization exercise program, the pain intensified and functional state deteriorated much faster than the maximum trunk muscle strength, leading to the conclusion that to reduce pain and improve function, regular exercise, not only improved strength and endurance, is necessary. We established that, although the 12-week lumbar stabilization exercise program increased multifidus muscle CSA and trunk muscles peak torque increased, disability and cLBP decreased, and these changes lasted for 2 months.

The limitation of this study is its short duration, as the long-term effects of lumbar stabilization exercise program in patients with cLBP remain unknown after 6 months of suspended exercises.

Conclusion

After 12-week lumbar stabilization exercises program, multifidus muscle CSA and trunk muscles peak torque increased, disability and cLBP decreased, and these changes lasted for 2 months.

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

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.

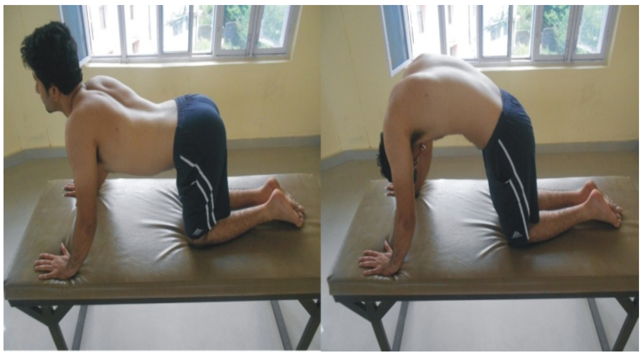


Figure 8: Cat and camel exercise.

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

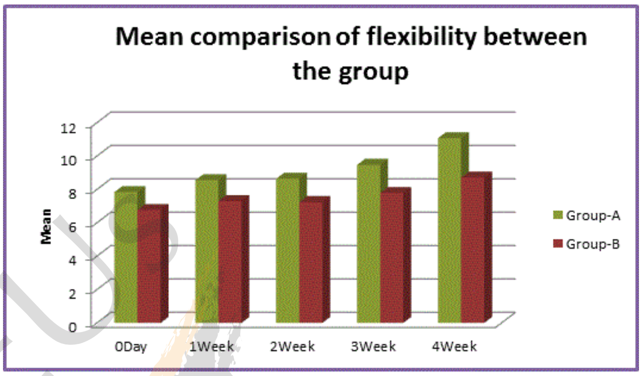
Table 1: Independent samples t-test between the groups.

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

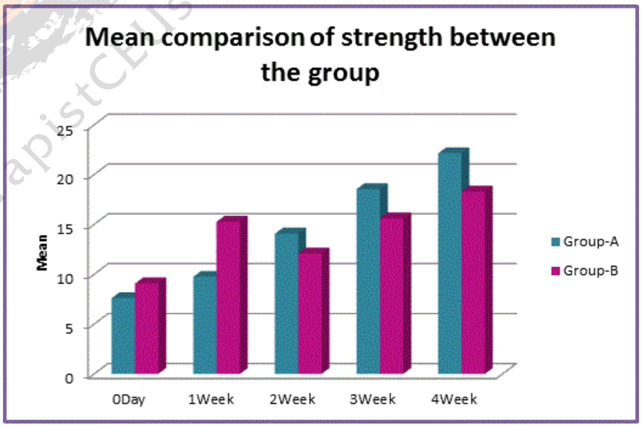
Table 2: ANOVA within group-A

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

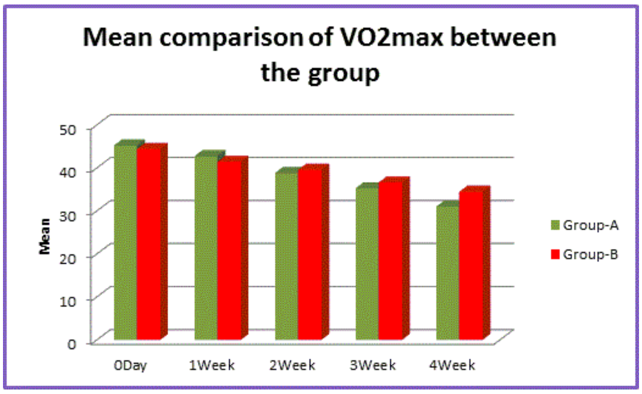
Table 3: ANOVA within group-B



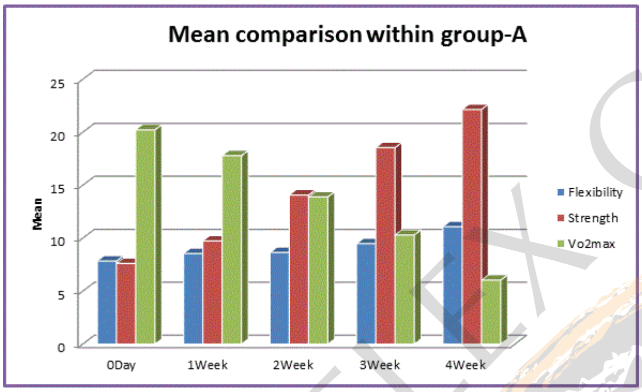
Graph 1: Mean comparison of flexibility within Group A and Group B at 0 day, 1st week, 2nd week, 3rd week and 4th week.



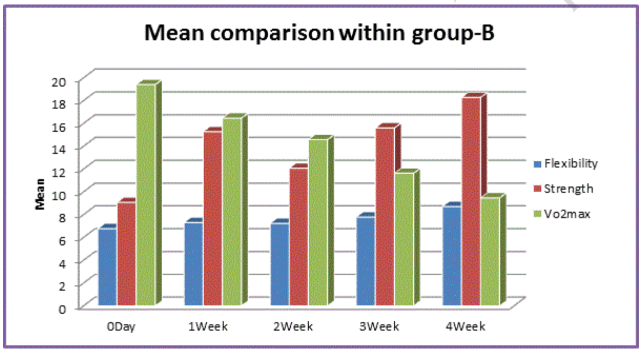
Graph 2: Mean comparison of strength within Group A and Group B at 0 day, 1st week, 2nd week, 3rd week and 4th week.



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.