International Journal of Physiotherapy and Research,
Int J Physiother Res 2020, Vol 8(5):3648-55. ISSN 2321-1822
DOI: https://dx.doi.org/10.16965/ijpr.2020.168

Original Research Article

COMPARISON OF CORE STRENGTHENING EXERCISES AND GENERAL TRUNK EXERCISES IN PATIENTS WITH CHRONIC LOW BACK PAIN USING LUMBO-PELVIC STABILITY TESTS AND PELVIC RADIUS TECHNIQUE

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ABSTRACT

Background: Core stability is defined as comprising of the lumbopelvic-hip complex and is the capacity to maintain equilibrium of the vertebral column within its physiologic limits by reducing displacement from perturbations and maintaining structural integrity. Over the years, the concept of core stability has changed and authors have highlighted the significance and contribution of the transversus abdominus muscle, especially, in lumbo pelvic stability. Upon this basis, it has now become an important part in the management of spinal stability. Thus, exercises relying on the activation, recruitment and strengthening the core muscles are a common avenue of treatment of chronic back pain. Pelvic compensation of the sagittal spinal alignment is important as it correlates to lumbar lordosis and overall sagittal balance. Hence pelvic radius technique (PRT) is used to measure the lumbar lordosis.

Context and Purpose of the study: To compare the effectiveness of core strengthening exercises and general trunk exercises on pain, lumbo-pelvic stability, lumbar lordosis and functional abilities in patients with chronic low back pain.

Results: Both exercise protocols showed statistically significant improved on Visual Analogue Scale (VAS), Oswetry Disability Index (ODI) and lumbo pelvic stability tests (LPS) (p value<0.05). For the lumbar lordosis only the core strengthening group showed statistically significant improvement (p value<0.05). When a comparison was done between groups it was statistically insignificant (p value<0.05).

Conclusion: The study the failed to show that core strengthening exercises are better than general trunk exercises on reducing pain, improving lumbo-pelvic stability, improving lumbar lordosis and functional abilities in patients with chronic low back pain. clinicians have a choice to either administer core stability exercise or general exercise when a patient has chronic non-specific low back pain.

KEY WORDS: Chronic back pain, Core strengthening, Lumbo-pelvic stability, Pelvic radius technique

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Access this Article online	Journal Information	
Quick Response code	**International Journal of Physiotherapy and Research** ISSN (E) 2321-1822 | ISSN (P) 2321-8975 **https://www.ijmhr.org/ijpr.html** **DOI-Prefix:** https://dx.doi.org/10.16965/ijpr	
	Article Information	
DOI: 10.16965/ijpr.2020.168	Received: 13 Sep 2020 Peer Review: 13 Sep 2020 Revised: None	Accepted: 29 Sep 2020 Published (O): 11 Oct 2020 Published (P): 11 Oct 2020

INTRODUCTION

Almost 60% people suffer from back pain once in a year and 22% turn chronic in nature [1]. In India, occurrence of low back pain is alarming; nearly 60 per cent of the people in India have significant low back pain at some time or the other in their lifespan. The real problem occurs when the pain becomes chronic and our day to day activities are hindered as a result. Chronic low back pain is defined as persistent pain occurring on most days and lasting longer than 3 months or is also defined as pain exceeding normal healing times and frequently reoccurring back pain over long periods [2].

One of the main reasons is the individual's occupation leading to severe postural deviation. Lifting heavy weights, sitting for long hours in front of the computer, pregnancy, even daily household chores lead to biomechanical changes and develop a faulty posture costing us our stability and mobility functions and resulting in pain. Hence, restoration of postural stability is of paramount importance. Conventionally, patients are given trunk muscle strengthening exercises to counter back pain and its consequences. However, there is growing evidence in literature about the efficacy of core stability exercises in the physiotherapeutic management of chronic back pain.

Core stability is defined as: "Comprising of the lumbo-pelvic-hip complex and is the capacity to maintain equilibrium of the vertebral column within its physiologic limits by reducing displacement from perturbations and maintaining structural integrity" [2].

Lumbo-pelvic stability (LPS) is a highly complex integrated function involving control of many segments of the body. This stability exists when the forces and the resulting moment acting on a structure maintain the structure in a state of equilibrium. LPS could be defined as the following: ''the ability of an individual to attain and then maintain optimal body segment alignment of the spine (lumbar and thoracic), the pelvis, and the thigh in both a static position and during dynamic activity. Stability is attained and maintained by passive structures and with optimal muscle recruitment patterns, that is, without substitution strategies" [3].

Panjabi made an important contribution by describing a neutral zone with minimal muscle activity around a neutral posture. Stability between vertebrae was provided by an interaction between active, passive, and neural systems [4]. Likewise, within the pelvis, stability is maintained by passive structures and active muscular forces.

Various functional tests have been reported in the literature. Of which there are a few visual observation clinical tests for measuring the lumbo-pelvic stability. These include single leg squat, dip test and runner pose. These are extremely easy tests and can be performed at any place. These tests also have an established criterion for rating the subjects as having good or poor lumbo-pelvic stability.

Many attempts have been made to quantify normal sagittal spinal alignment and lordosis using a C7 plumb line and segmental angulations of the spinal vertebrae. Little attention has been given to pelvic compensation as it correlates to lumbar lordosis and overall sagittal spinal alignment [5]. So, now a day's pelvic radius technique is used to measure the lumbar lordosis. Understanding this measurement and the range of lumbo-pelvic compensation can be extremely helpful in treating patients with spinal pathology and in avoidance of the subsequent flat back deformity. Application of these measures would be especially helpful in the treatment of patients with spinal fusion, degenerative spondylosis, disc disease, fractures, and in the prevention of sagittal mal alignment.

Thus, this study was aimed to find out if core stabilization exercises are better than general trunk exercises for improvement of lumbo-pelvic stability using lumbo-pelvic stability tests and pelvic radius technique.

METHODS

The research was designed as a prospective experimental comparative study. Approval from the Institutional Ethics Committee (IEC) was sought. Participants were included in study after screening for inclusion and exclusion criteria.

Inclusion criteria included patients suffering from chronic low back pain above the age of 18 years, ability to understand the purpose of the study and follow up for 6 weeks,_voluntary consent to participate.

Exclusion criteria included patients with radicular pain, spondylolisthesis, vertebral or pelvic fractures, patients with rheumatic disorders, traumatic back pain, spinal cord infections, vertebral instability, sacro-iliac joint dysfunction, neurological or cardiopulmonary problems, lower limb osteoarthritis, participation in any physical training activities, inability to understand and co-operate, pregnant females.

A written consent was taken from the participants after explaining the procedure of the study. The basic personal information, anthropometric measures, occupation history, co-morbidities and information regarding current medication of the participant was recorded.

Each Participant's Visual Analogue Scale (VAS) and Oswestry Disability Index [6] (ODI) score was taken. Patients were asked to perform the three lumbo-pelvic stability tests: Single leg squat, Dip test and Runner pose and a video was taken while the patient assumed those positions. Patients were given a trial before recording the movement. The patient was rated as good or poor according to the criteria for lumbo-pelvic stability tests [3]. The lumbar lordosis was measured on x-ray using the pelvic radius technique. They were then randomly allocated by means of opaque envelopes to one of two treatment Groups namely; those who were to receive core strengthening exercises (Group A) and those who were to receive general trunk exercises (Group B). Equal numbers of envelopes were made for both treatment Groups.

Outcome measures were assessed as Primary and Secondary Outcomes**. Primary outcomes** included [A] Lumbo-Pelvic stability measured using Lumbo-pelvic stability tests: 1) Single leg squat, 2) Dip test and 3) Runner pose. [B] Pelvic radius technique to measure lumbar lordosis. **Secondary outcomes** included [A] Pain measured as intensity at rest on a 10 cm VAS in cm and [B] Activity limitation in terms of loss of function measured on Oswestry Disability Index.

The protocols for treatment were pre-defined and outlined for both the Groups A and B as noted in Tables 1 and 2 [7].

Table 1: Protocol for core strengthening (Group A).

WEEK	PROTOCOL
	1. Exercises for the TrA in 4 point kneeling; 2. Exercises for the TrA in dorsal decubitus with flexed knees; 3. Exercises for the LM in ventral decubitus; 4. Co-contraction of the TrA and LM in upright position.
1-2 WEEKS	Teaching activation transverse abdominis by in drawing the lower abdominals and longissimus multifidus by contracting the paraspinals around L4. L5
3-5 WEEKS	Training the patient to maintain the contraction for 10 seconds × 10 repetitions (3 SETS)
6 WEEK	Exercise on unstable surface. Lumbo-pelvic control in sitting using gym ball. Lumbo-pelvic control in standing using tilt board.

Table 2: Protocol for general trunk exercises (Group B).

WEEKS	PROTOCOL
	1. Exercises for the RA in dorsal decubitus with flexed knees: trunk flexion; 2. Exercises for the RA, IO and EO in dorsal decubitus and flexed knees: trunk flexion and rotation; 3. Exercises for the RA in dorsal decubitus and semi-flexed knees: hip flexion; 4. Exercises for the ES in ventral decubitus: trunk extension.
1-2 WEEKS	Teaching the patient to perform 3 sets of these exercises for 10 repetitions with grade 3 strengthening
3-5 WEEKS	Training the patient to perform 3 sets of these exercises for 10 repetitions with grade 4 strengthening
6 WEEK	Training the patient to achieve 3 sets of these exercises for 10 repetitions with grade 5 strengthening

*The patients were progressed to next higher grading only if the acceptable previous grading was achieved. For progression to grade 4 and 5 the subjects were made to perform the exercises with a change in the upper limb position.

The intervention period lasted 6 weeks. Patients received treatment thrice a week for six weeks. Both Groups were given hotpacks for pain relief for 20 mins and a warm-up exercise period including stretching exercises and stationary bicycling for 10–15 minutes. At the end of six weeks the patients were asked to take another X-ray. The lumbar lordosis using the pelvic radius technique was measured again. Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI) were taken again. The patients were asked to perform lumbo-pelvic stability tests. Videos were taken again and patients were rated based on the criteria.

The total duration of study was 15 months with a calculated sample size: 40 (20 in each group). The sample population comprised of patients suffering from chronic low back pain. The source of sampling was patients with chronic low back pain coming to the outpatient department (opd) of a tertiary health care hospital.

Data was analysed using SPSS 16.0 software. Descriptive analysis of data was done. Data was tested for normality using the Shapiro-Wilk test. For data passing the normality tests, parametric tests like paired t test and unpaired t test were used within the Group and between the Groups respectively. The level of significance was set at 0.05.

RESULTS AND DISCUSSION

40 volunteers who fulfilled the inclusion and exclusion criteria were included in the study. 40% were females and 60% were males. The age of patients ranged from 18-60 years. Mean age in each group was similar, 33.85 years in Group A and 34 years in Group B. It is a common finding that low back pain occurs in the age Group of 30 to 45 years [8] which is the working age group and hence more susceptible to injury. The patients were divided into two groups, 20 in each group.

Vas and Oswestry Disability Index being ordinal scales, data within group were analyzed using the non-parametric Wilcoxon Signed Rank test. Between groups the difference between pre and post values were calculated and the data were analyzed using Mann-Whitney U test. The results were found statistically non significant at $p>0.05$, for a two-tailed test.

The Pain-spasm-pain cycle is one of the most common reasons for dysfunction and disability related to musculoskeletal conditions. This theory proposes that when an injury occurs there is a reflexive response from the surrounding musculature to become hypertonic and brace the injured structure to prevent further injury [9,19]. However, if the contraction of the musculature is maintained for an extended period of time a deleterious effect occurs in which the muscles themselves become a source of pain, therefore propagating the pain spasm- pain effect [9].

For the all three lumbo-pelvic stability tests the data was converted into binomial distribution where GOOD = 1 and BAD = 0. And sum of all the three tests for pre and post was calculated. Wilcoxon Signed Rank test was used within the group. Difference between pre and post values was calculated and Mann-Whitney U test was used to compare between the groups. It was found statistically insignificant, suggesting that both Groups of exercises showed similar outcomes on lumbo-pelvic stability.

This pain model has a significant relationship to *Panjabi et al*'s (1992) theory of spinal stability, that when there is a sustainable damage to the passive structures, the active structures adjust automatically through altered neuromuscular firing patterns [10]. This results in a continuous vicious cycle of pain-spasm-pain. It has been suggested in previous studies that a central widespread inhibitory mechanism is activated with muscle contractions. The central mechanisms include increased secretion of β endorphins, attenuation mechanisms, activation of diffuse noxious inhibitory controls, or an interaction of the cardiovascular and pain regulatory systems [11]. There is hypoanalgesia post exercise. In our study also exercises can be a reason to reduce pain. Therefore, after exercising, the muscles relax and there is a release in the spasm of hypertonic muscles along with release of neurotransmitters. These mechanisms of the central nervous system lead to alleviation in pain. Results of our study are supported by *Franca et al* who found out that the co-contraction of the TrA and LM muscles is the basis of the lumbo-sacral biomechanical stability and that these muscles act by reducing the compressive overloads thereby attenuating or eradicating pain perception [7].

Stability of the spine is provided by the integrated relationship of three sub-systems: (1) active, (2) passive, and (3) control (central) as told by *Panjabi et al*. [10] For maintaining lumbar spinal stability the three sub systems interact in the following manner: the passive support system relies on the ligaments and fascias of skeletal muscles; the active contraction system, in which lumbar spinal movement and stability are maintained by contracting the core muscles; and the central nervous system, plays a leading role in motor control [12]. The muscle forces generated to stabilize the spine are often several times larger than the external load and body weight combined and these large muscle forces are also responsible for most compressive and shear forces placed on the spine. Under sudden loading conditions, peak muscle forces in the trunk are much greater than under static conditions and even more extreme under sudden and unexpected loading [13].

This leads to injuries and chronic mechanical derangement in the osteoligamentous structure reduce spinal stability. Chronic non specific low back pain (CLBP) is a result of overuse and results from cumulative trauma as mentioned above. An adequate response to sudden loading depends not only on a sufficient muscle force but also on correct muscle recruitment and timing patterns to assure the mechanical stability of the lumbar spine [13]. Optimal firing and synchronization of all core muscles is proposed to be necessary for the greatest amount of spinal stability [9].

It has been demonstrated that transversus abdominis is selectively activated prior to limb movement at different speeds, but activation is inhibited in patients with a history of low back pain and it is thought to play a major role in spinal stability as it increases intra-abdominal pressure and places tension on thoracolumbar fascia when contracted [9]. The diaphragm and the pelvic floor, respectively make up the two sides of the "box" that forms the core. Their primary contribution to lumbar stability is through cocontraction with the abdominals to increase intra- abdominal pressure, thus creating a rigid cylinder or an anatomical back brace to decrease the load on the spine. [9] There is little evidence however that clearly identifies its function in providing lumbar stability as research has been inconclusive to date regarding transverse abdominis' capacity to provide segmental stabilization but it is clear that it can create multidirectional lumbar stability based on their anatomical orientation in the musculoskeletal system [9].

CLBP patients make use of a different postural motor strategy to maintain quiet stance as a consequence of an imprecise internal estimate of body sway, due to reduced accuracy in the sensory integration process [14]. This could be the reason subjects clawed their toes in single leg stance. Also, LBP diminishes the normal velocity-induced transverse counter-rotation between thorax and pelvis, and that it globally affects mean erector spinae (ES) activity [15]. These along with weak muscles leads to disturbance in alignment, altered movement like side bending, trembling and sway during weight transfers from one leg to other.

But *Jull et al* have stated that activating specific "local stabilizers" such as transverse abdominis and lumbar multifidi play a large role in stabilization during dynamic movement and loading of the spinal column [16]. Other researchers however, state that activation of all stabilizing muscles is important for increasing stability in the lumbar region and no one muscle can be identified as contributing greatest to stability [17]. So strengthening both groups of muscles is equally important. Contrary to our findings *Franca et al* in their study found that although both the exercise protocols showed improvement but the Improvement in all variables was superior in the segmental stabilization group opposed to the strengthening Group [7].

Results of our study are supported by many authors, compilation of which is done in the meta analysis *'Myth of core stability' by Eyal Lederman* where he stated that it is doubtful that there exists a "core" Group of trunk muscles that are recruited and operate independently of all other trunk muscles during daily or sport activities [18]. Similarly, *Beith et al* stated that it would be next to impossible to contract a single muscle or specific Group. Even with extensive training this would be a major problem [19]. Indeed, there is no support from research that TrA can be singularly activated. The control of the trunk (and body) is whole. Pelvic radius technique was tested for normality using Shapiro-wilk. It passes the normality and hence to compare the per- and post-intervention data, paired't' test was used within

Groups. Difference between pre and post values was calculated and unpaired't' test was used between Groups. On applying paired t-test, results were statistically significant with a p value < 0.05. It suggests that after following the core strengthening exercises protocol for 6 weeks there is a minute change in the angle of an increase in lumbar lordosis when measured according to the pelvic radius technique. When compared within group for GSTM exercises no statistical significance was found in the lumbar lordosis post 6 weeks of treatment. When Independent samples test (Unpaired 't' test) was applied to the difference in pre and post angles in both the Groups, the results showed no statistical significance that core strengthening is better than GTMS in correcting the obliterated lumbar lordosis measured using the pelvic radius technique.

In the core strengthening Group, there is a local segmental stabilization as these muscles attach directly to the vertebrae as oppose to the global group of muscles. Hence, when we train the core muscles they increase the stability and help to maintain the lumbo-pelvic alignment. With reduction in pain and as a result reduction in spasm, stretching of shortened soft tissues and simultaneous strengthening of the core muscles results in a cumulative effective on the alignment of the vertebral column [20].

Although, Group A individually showed better improvement when Paired 't' test was applied, but may be the difference was not large enough to get detected statistically when compared on Independent samples test (Unpaired 't' test) or the sample size wasn't large enough to detect a statistically significant difference. Activation of core strengthening indirectly leads to activation of superficial trunk muscles and vice versa. This can be the reason for having same outcomes in both Groups. The mode of action of retraining in stabilization exercises still remains unclear, because even upon improvement of muscle activation it is not been shown capable of stabilizing a mechanically unstable segment and no direct long term effect of stabilization exercises on the status of the local stabilizing muscles has been demonstrated [21].

This suggests that not only local muscles like transverses abdominis and longissimus multifidus but also erector spinae and rectus abdominis which is are global muscles help in maintaining the spinal alignment and to carry out movement.

Kaumantakis et al found that general exercise program reduced disability in the short term to a greater extent than a stabilization–enhanced exercise approach in patients with recurrent nonspecific low back pain. Stabilization exercises do not appear to provide additional benefit to patients with subacute or chronic low back pain who have no clinical signs suggesting the presence of spinal instability [21]. Plail et al in their meta-analysis study showed that core stability exercise had signficant improvement in both pain and function compared to general exercise for patients with chronic low back pain. However, they concluded that clinicians have a choice to either administer core stability exercise or general exercise when a patient has chronic non-specific low back pain. Core stability exercise can be used as an alternative to general strengthening and stretching if patient is more suitable and if it would encourage compliance. However, clinicians should not expect a significant improvement by choosing core stability in regards to pain and function especially in the long term [2].

CONCLUSION

Core strengthening exercises are effective in reducing pain, improving lumbo-pelvic stability, improving the lumbar lordosis and functional abilities in patients with chronic low back pain. General trunk exercises are effective in reducing pain, improving lumbo-pelvic stability and functional abilities but show no effect on lumbar lordosis in patients with chronic low back pain. However, the study the failed to show that core strengthening exercises are better than general trunk exercises on reducing pain, improving lumbo-pelvic stability, improving lumbar lordosis and functional abilities in patients with chronic low back pain. Core strengthening exercises and general trunk exercises are both efficacious in treatment of chronic non specific low back pain. A multimodal approach should be used including the testing of lumbopelvic stability.

ABBREVIATIONS

PRT - Pelvic radius technique –PRT
VAS - Visual Analogue Scale – VAS
ODI - Oswestry Disability index – ODI
LPS - Lumbo pelvic stability tests – LPS
OPD - Outpatient Department – OPD
TrA - Transverse abdominis – TrA
LM - Longissimus multifidus – LM
RA - Rectus abdominis – RA
IO - Internal oblique – IO
EO - External oblique – EO
ES - Erector spinae – ES
CLBP - Chronic non specific low back pain – CLBP

Conflicts of interest: None

ACKNOWLEDGEMENTS

I would like to acknowledge my former Head of Physiotherapy Department, Mrs Hutoxi Writer, for her support and guidance throughout the process and a special appreciation to the Dean of Topiwala National Medical College.

REFERENCES

[1]. Elders LAM, Burdorf A. Prevalence, incidence, and recurrence of low back pain in scaffolders during a three year follow-up study. Department of Public Health, Erasmus MC, University Medical Center Rotterdam. Maetis arbo, Occupational Health Service Rotterdam. Page 20-30.

[2]. Plail J, Moysey Y, Sheehy T et al. The effectiveness of core stability exercise with regards to general exercise in the management of chronic back pain. Nottingham University Spinal Rehabilitation Project.

[3]. Perrott MA, Pizzari T, Opar M et al. Development of Clinical Rating Criteria for Tests of Lumbo-pelvic Stability. Rehabilitation Research and Practice Volume 2012, Article ID 803637, 7 pages. https://doi.org/10.1155/2012/803637 PMid:22263111 PMCid:PMC3255301

[4]. Panjabi MM. The stabilizing system of the spine-part II: neutral zone and instability hypothesis. Journal of Spinal Disorders 1992;5(4):390-397. https://doi.org/10.1097/00002517-199212000-00002 PMid:1490035

[5]. Sergides IG, McCombe PF, White G et al. Lumbo-pelvic lordosis and the pelvic radius technique in the assessment of spinal sagittal balance: strengths and caveats. Eur Spine J. Sep 2011; 20(Suppl 5): 591-601. https://doi.org/10.1007/s00586-011-1926-z PMid:21863464 PMCid:PMC3175929

[6]. Fairbank JC, Pynsent PB. The Oswestry Disability Index. November 15, 2000;25(22):2940-2953. https://doi.org/10.1097/00007632-200011150-00017 PMid:11074683

[7]. Franca FR, Burke TN, Hanada ES, et al. Segmental stabilization and muscular strengthening in chronic low back pain - a comparative study. CLINICS 2010;65(10):1013-1017 https://doi.org/10.1590/S1807-59322010001000015 PMid:21120303 PMCid:PMC2972594

[8]. Kisner C, Colby LA. Therapeutic Exercise Foundations and Techniques. 6th Edition, Jaypee Brothers Medical Publishers (P) Ltd: 2013. Chapter 14, The Spine and Posture, Pages: 417 - 421.

[9]. Johnson J. Functional Rehabilitation of Low Back Pain With Core Stabilization Exercises: Suggestions for Exercises and Progressions in Athletes (2012). All Graduate Plan B and other Report, Paper 170.

[10]. Panajbi, MM. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. Journal of Spinal Disorders & Techniques, 1992a; 5(4):383-389. https://doi.org/10.1097/00002517-199212000-00001 PMid:1490034

[11]. Naugle KM, Fillingim RB, Riley III JL. A meta-analytic review of the hypoalgesic effects of exercise. The Journal of pain. 2012 Dec 1;13(12):1139-50. https://doi.org/10.1016/j.jpain.2012.09.006 PMid:23141188 PMCid:PMC3578581

[12]. Chang WD, Lin HY, Lai PT. Core strength training for patients with chronic low back pain. J. Phys. Ther. Sci. 2015;27:619-622. https://doi.org/10.1589/jpts.27.619 PMid:25931693 PMCid:PMC4395677

[13]. Radebold A, Cholewicki J, Panjabi MM et al. Muscle Response Pattern to Sudden Trunk Loading in Healthy Individuals and in Patients with Chronic Low Back Pain. Spine:15 April 2000;25(8):947-954. https://doi.org/10.1097/00007632-200004150-00009 PMid:10767807

[14]. Popa T, Bonifazi M, Della Volpe R. et al. Adaptive changes in postural strategy selection in chronic low back pain. Exp Brain Res 2007;177: 411. https://doi.org/10.1007/s00221-006-0683-4 PMid:16977448

[15]. Lamoth CJC, Meijer OG, Daffertshofer A. et al. Effects of chronic low back pain on trunk coordination and back muscle activity during walking: changes in motor control. Eur Spine J. 2006;15:23. https://doi.org/10.1007/s00586-004-0825-y PMid:15864670 PMCid:PMC3454567

[16]. Jull GA & Richardson CA. Motor control problems in patients with spinal pain: a new direction for therapeutic exercise. Journal of Manipulative Physiological Therapeutics, 2000;23(2):115-117. https://doi.org/10.1016/S0161-4754(00)90079-4 https://doi.org/10.1067/mmt.2000.104081 PMid:10714539

[17]. Vera-Garcia JF, Elvira JJ, Brown S et al. Effects of abdominal stabilization maneuvers on the control of spine motion and stability against sudden trunk perturbations. Journal of Electromyography and Kinesiology, 2007;17:556-567. https://doi.org/10.1016/j.jelekin.2006.07.004 PMid:16996278

[18]. Lederman E. The myth of core stability. Journal of Bodywork and Movement Therapies, 2010;14(1): 84-98. https://doi.org/10.1016/j.jbmt.2009.08.001 PMid:20006294

[19]. Beith ID, Synnott RE, Newman SA. Abdominal muscle activity during the abdominal hollowing manoeuvre in the four point kneeling and prone positions. Man. Ther., 2001;6(2):82-87. https://doi.org/10.1054/math.2000.0376 PMid:11414777

[20]. Nourbakhsh MR and Arab AM. Relationship between Mechanical Factors and Incidence of Low Back Pain. Journal of Orthopaedic & Sports Physical Therapy. 2002 Sep;32(9):447-60. https://doi.org/10.2519/jospt.2002.32.9.447 PMid:12322811

[21]. Koumantakis GA, Watson PJ and Oldham JA. Trunk Muscle Stabilization Training Plus General Exercise Versus General Exercise Only: Randomized Controlled Trial of Patients With Recurrent Low Back Pain. Physical Therapy. 2005;85(3). https://doi.org/10.1093/ptj/85.3.209 PMid:15733046

How to cite this article:

Disha Shah, Swati Kubal. COMPARISON OF CORE STRENGTHENING EXERCISES AND GENERAL TRUNK EXERCISES IN PATIENTS WITH CHRONIC LOW BACK PAIN USING LUMBO-PELVIC STABILITY TESTS AND PELVIC RADIUS TECHNIQUE. Int J Physiother Res 2020;8(5):3648-3655. **DOI:** 10.16965/ijpr.2020.168