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Effect of Lumbar Stabilization Exercise on Spinal Instability in Patients With Low Back Pain: A Literature Review

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국문요약

요추부 안정성 운동이 요통 환자의 척추 불안정성에 미치는 영향: 문헌고찰

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요통은 산업화된 현대사회에서 흔히 발생하는 질환이다. 요통의 다양한 원인 중에서도 척추의 정상 가동범위를 넘은 불안정성이 요통의 한 원인으로 보고되고 있다. 이 문헌고찰의 목적은 요추 부위의 안정성을 부여하는 운동 프로그램 후 근육 기능의 강화, 통증의 감소를 보고한 논문들을 비교, 분석하는 것이다. 그리하여 요통의 한 원인인 척추의 안정성을 증가시켜 요추 부위의 통증을 감소시키고 기능을 향상시키는 운동 프로그램의 효과를 입증하는 것이다.

핵심단어: 척추 불안정성; 요추 안정성.

Introduction

Low back pain (LBP) is one of the most common and costly medical problems in modern industrialized societies (Coste et al, 1991; Graves et al, 1990; O'Sullivan, 2000). Back pain is the most common complaint seen by physical therapist; it is also the symptom most often associated with the use of modalities. It has been estimated that 8 of 10 people will suffer from LBP at some time in their lives at a lost of billions of dollars annually (Coste et al, 1991; Graves et al, 1990). Although the etiology of LBP is diverse, many causes have been related to weakness or injury of the soft tissue in the lumbar area (Begmark, 1989; O'Sullivan, 2000; O'Sullivan et al, 1997; Pangabi, 1992; Richardson and Jull, 1995). Muscles play an important role in the etiology, presentation and treatment of low back disorder. It is known clinically that excessive motion beyond the normal physiologic limits, also sometimes referred to as spinal instability, may result in chronic low back pain (Hodges and Richardson, 1996). Panjabi (1992) defined spinal instability in terms of a region of laxity around the neutral resting position of a spinal segment called the neutral zone. The neutral zone is shown to be larger with intersegmental injury and intervertebral disc degeneration and smaller with simulated muscle forces across a motion segment. Begmark (1989) hypothesized the presence of two muscle systems that act in the maintenance of spinal stability. The global muscle system consists of large torque producing muscles that act on the trunk and spine without directly attaching to it. These muscles include rectus abdominis, oblique abdominis externus, and the thoracic part of lumbar iliocostalis. These muscles provide general trunk stabilization but are not capable of having a direct segmental influence on the spine. The local muscle system consists of muscles that directly attach to the lumbar vertebrae, and they are responsible for providing segmental stability and directly controlling the lumbar segments. Lumbar multifidus, psoas major, quadratus lumborum, the lumbar parts of the lumbar iliocostalis and longissimus, and transversus abdominis form part of this local muscle system.

In a recent study by Hides and his associates (1996) it was concluded that retraining of the deep muscle cocontraction could reverse the inhibition of the lumbar multifidus demonstrated by patients with a first episode of acute low back pain. In addition, there is increasing evidence that lumbar multifidus and transversus abdominis are preferentially affected in the presence of low back pain and lumbar stability (Hides et al, 1996; Hides et al, 1994). Specific submaximal training of these stability muscles of the lumbar spine decreased both pain and functional disability in those suffering from mechanical LBP (Richardson and Jull, 1995). Clinically, this approach appears particularly effective when the segmental stability of the lumbar spine has been compromised.

Further understanding of the effects of spinal stabilization exercise and motor control are necessary for the effective treatment of LBP. The purpose of this study was to determine the effects of spinal stabilization exercise, which strengthens local muscle system and decreases pain in patients with LBP. It is hypothesized that lumbar spinal stabilization exercises will increase spinal stability, and decrease pain responses.

Methods

Two articles were reviewed for the concerning topic. These two articles were found to be the most pertinent to be reviewed because they proved the effect of spinal stabilization exercise in patients with low back pain.

The first article (O'Sullivan et al, 1997) looked at the effect of specific stabilizing exercise in the treatment of chronic low back pain. The second article (Hides et al, 1996) investigated the effectiveness of specific and localized exercise therapy.

Subjects and Data Collection

Forty-four patients were assigned randomly to two treatment groups. According to inclusion criteria, the sample consisted of 44 patients of either gender between the ages of 16 and 49 whose LBP symptoms (with or without pain extension into the lower limbs) were recurrent and had persisted longer than 3 months with no sign of abating. Patients were excluded from entry to the trial if they had: a clinical presentation considered not attributable to the presence of the spondylolysis or spondylolisthesis by the treating medical specialist; a diagnosed psychological illness; difficulty understanding English, precluding them from answering the questionnaires; previous spinal surgery; or an inflammatory joint disease or displayed overt neurological signs (sensory or motor paralysis). Patients were recruited from general and specialist medical practices, pain management clinics, and physical therapy practices.

Proper procedures for informed consent were followed. Patients were selected on the basis of their symptoms and clinical presentation being considered attributable to the radiologic diagnosis of spondylolysis or spondylolisthesis by their treating medical specialist.

A number of factors were combined to limit the generalizability of this study. First, small sample size limited the generalizability of results because: small groups tended to be less representative of target populations; random assignment to conditions can be less successful; and the statistical power of the analytical procedures was limited. Another limitation of this study was the lack of exercise supervision, which decreased internal validity. Second, this study measured pain and functional disability using the short form of questionnaire. This measurement was quite subjective. Specific exercise group underwent a 10 week treatment program directed by one of four different physical therapists. This study did not have written standardized guidelines for exercises, which may lead the lack of internal validity.

Authors believed that McGill pain questionnaire was sufficiently sensitive to demonstrate differences at statistical levels. Also, Oswestry disability questionnaire was used to give a percentage score that indicated each patient's level of functional disability. This questionnaire was thought to be sufficiently sensitive to monitor these changes.

This study used a Cybex Electronic Digital Inclinometer to evaluate lumbar spine and hip sagittal range of motion in standing. The repeatability of the inclinometer for measuring lumbar curvature in the population with chronic low back pain has been established and validated against lumbar spine radiographs.

Surface electromyography was also used to report abdominal muscle recruitment patterns. This maneuver has been found in the literature.

Authors mentioned that this maneuver has been found in the healthy muscles to activate the deep abdominal muscles with minimal activity of the rectus abdominis.

A randomized, controlled clinical trial, test-retest design with two treatment groups and a blind investigation were used. After completion of the initial testing, the patients were randomly assigned to either the specific exercise group (SEG) or a control group (CG). During the following four month period, they were allocated to either group. The intervention period was 10 weeks. At the completion of the intervention period, patients were again tested by the same investigator blinded to group allocation. Subjects were then reassessed by postal questionnaire for a 3, 6, and 30 month follow-up. The SEG underwent a 10 week treatment program on a weekly basis by one of four manipulative physical therapists. The exercises were designed to: 1) train the specific contrac- tion of the deep abdominal muscles without substitution from large torque producing muscles such as rectus abdominis and external oblique using the abdominal draw- ing in maneuver; and 2) train specific contraction of deep abdominal muscles with 10 activation of lumbar multifidus proximal to the pars defect.

The exercise program stressed that these exercises were precise isometric contractions and were designed to take approximately 10 15 minutes with a daily basis. The hold time for these exercises was increased gradually the point when patients were able to perform 10 contractions with 10 second holds.

Experimental group performed an isometric spinal stabilization exercise program twice a week for 15 minutes. Subjects was asked to complete exercise sheet to monitor their compliance.

Exercise programs were as follows:

1. In four point kneeling, subjects draw abdominal wall up and in and hold this position for 10 seconds. The rib cage and pelvis should remain still, and the subjects must continue to breathe normally throughout the abdominal drawing in and holding contraction.

2. In prone, subjects draw lower abdominal wall up and in while maintaining neutral lordosis. The rib cage and pelvis should remain still, and the subject must continue to breathe normally.

3. In sitting and upright standing, subject draw abdominal wall up and in to facilitate the contraction of the pelvic floor and lower and middle fibers of transversus abdominis with gentle controlled lateral costal diaphragm breathing without global muscle substitution.

Statistical Design

1. Repeated measures analysis of variance was used: 1) to assess for group differences at entry to the trial on the baseline data; 2) to assess change within each group after the intervention period; 3) to assess differences between the two groups after the intervention period on the change scores (the difference between the follow-up score and the baseline score for each individual) of each measure.

2. Two-way repeated measures analysis of variance was carried out on the questionnaire data to assess differences within and between the groups after the intervention and at the 3, 6, and 30 month follow-up. The level for statistical significance was set at the 95% confidence limit.

Subjects and Data Collection

Men and women were recruited for the study in the first instance if they were: 1) aged 18-45 years; 2) experiencing their first episode of unilateral and mechanical LBP between T_{12} and the gluteal fold (with or without pain radiation into the lower limb); and 3) showing restricted range of lumbar motion. Exclusion criteria were previous history of LBP or injury, previous lumbar surgery, spinal abnormalities indicated on radiographs, neuromuscular or joint disease, reflex and/or motor signs of nerve root compression or cauda equina compression, evidence of systemic disease, carcinoma or organ disease, pregnancy, and any sports or fitness training involving the low back muscles done in the past 3 months.

Forty-one patients were accepted provisionally into the study. Random assignment to the control (group 1, medical management) or the treatment group (group 2, medical management and specific exercise therapy) was achieved by selecting the group number (one or two) from sealed and shuffled envelopes. Twenty patients were allocated randomly into group 1, and 21 patients were allocated into group 2. There were 10 men and 10 women in group 1, and 8 men and 13 women in group 2. The mean age of patients in group 1 was 31.0±7.9 years (range, 17 45 years), and the mean age for patients in group 2 was 30.9±6.5 years (range, 22 44 years).

The article stated that informed consent was obtained from the subjects. The study was approved by the Medical Ethical Review committees of the University of Queensland and the Mater Adult Hospital, Brisbane, Australia.

Key terms that the authors identified were: 1) range of motion (ROM) referring to full motion possible; 2) straight leg raise (SLR) referring to hip flexion without bent knee.

This study's limitations were that it was not a purely random sampling from an all inclusive population. Inclusion criteria was too strict so that this study lost couple of subjects

Assumptions of the study was that localized physical training, which can restore muscle size at the segmental level, may be a necessary at the first stage of rehabilitation before more generalized stabilization training, therefore, muscle control at the segmental level might be better assured. It was assumed that asymmetry between each side of the lumbar spine has to be greater than 11% for patients to be considered for study. Authors also believed that multifidus muscle dysfunction in patients with acute LBP also could be related to outcome and recurrence of LBP symptoms.

The following equipment was utilized: 1) lumbar motion was measured using a two-inclinometer method for lumbar flexion; and 2) extension and a single-inclinometer method was used for lumbar lateral flexion. Oil-filled Rippstein goniometers were used for all measurements of lumbar motion. SLR also measured using the oil-filled goniometer. Measurement of multifidus cross sectional area was measured using real-time ultrasound imaging. All ultrasound imaging was performed by the blinded ultrasonographer using real-time ultrasound apparatus (Toshiba Sonolayer V SSA-100A, Toshiba Medical Systems, Japan) equipped with a 5 MHz convex array transducer.

All subjects were assessed initially to provide baseline data and then reassessed weekly for 4 weeks. Patients who did not attain full pain-free function were removed from the study at 4 weeks. The remaining patients were reassessed during the 10th week of the study. Habitual activity levels and muscle cross sectional area were determined at 10th weeks.

Medical management of the low back pain for the control group included advice on bed rest and minor analgesics. Experimental group received medical management and therapeutic exercises which were designed to re-educate the multifidus muscle. They involved facilitating in active and isometric multifidus contraction in co-contraction with the deep abdominal muscles.

Comparability of baseline measurements between the groups was assessed using one-way analysis of variance (ANOVA) to examine differences in all baseline measurements. Analysis of variance also was used to examine differences between groups over time for all outcome measures used. If patients did not have localized and segmental muscle asymmetry at the time of this first assessment, their data were not included in further analysis. Analysis of variance also was used to examine the data from the other vertebral levels measured during the first week. Correlation analysis was used to test for relationships among muscle recovery, pain, disability, and range of motion.

Results

For the purpose of the results section, the research studies mainly focus on the efficacy of specific stabilizing exercise. The studies that focused on efficacy of specific stabilizing exercise unanimously agreed that it decreases pain and increased functional disability level (Hides et al, 1996; Hides et al, 1994; O'Sullivan. 2000).

Analysis of differences within each group after the intervention period revealed significant differences in the specific exercise group after the intervention period ($p<.05$) with a decrease in pain intensity ($F=75.5$, $df=1.20$, $p<.0001$), pain descriptor scores ($F=35.8$, $df=1.20$, $p<.0001$), and a reduction in functional disability level ($F=49.1$, $df=1.20$, $p<.0001$).

Analysis of the follow-up data revealed significant differences between the specific exercise group and control group on the basis of pain intensity ($F=14.4$, $df=1.32$, $p=.0006$).

Analysis of group differences on the basis of the pain descriptor scores revealed significant differences between the specific exercise group and control group ($F=6.1$, $df=1.32$, $p=.0187$).

Hides and his associates (1996) investigated the effectiveness of specific and localized exercise therapy on muscle recovery. Patients in group 1 received medical treatment only. Patients in group 2 received medical treatment and specific and localized exercise therapy. Patients were reassessed at a 10 week follow-up examination. Hides and his associates used ultrasound imaging to measure multifidus cross-sectional area. This study revealed that multifidus muscle recovery was not spontaneous on remission of painful symptoms in patients in group 1. Muscle recovery was more rapid and more complete in patients in group 2 who received exercise therapy.

Analysis of variance revealed that total muscle recovery ($F=103.5$, $df=1.14$, $p=.0001$) and weekly muscle recovery ($F=34.75$, $df=4.14$, $p=.0001$) differed significantly between groups.

Discussion and Conclusions

There has been growing interest in how the neuromuscular system supports and controls the spinal segment. Support is growing for the functional differentiation between global and local muscles in relation to spinal control. More pertinently, links are now emerging between low back pain and motor control deficits in muscles of the local system, notably the transverses abdominis and lumbar multifidus (Hides et al, 1996; Hides et al, 1994; Hodges and Richardson, 1996). Lumbar multifidus has been shown to react by inhibition at a segmental level in acute episodes of low back pain (Hides et al, 1996; Hides et al, 1994). O'Sullivan and his associates (1992) demonstrated that specific exercise training of the stability muscles of the trunk is effective in reducing pain and functional disability in patients with chronically symptomatic spondylolysis and spondylolisthesis. Crisco and Panjabi (1991) reported that lumbar stability is maintained in vivo by increasing the activity (stiffness) of the lumbar segmental muscles. They also emphasized that the importance of motor control to coordinate muscle recruitment between large trunk muscles and small intrinsic muscles during functional activities to ensure stability is maintained. The concept of different trunk muscles playing different roles in the provision of dynamic stability to the spine was proposed by Begmark (1989). He hypothesized the presence of two muscle systems in the maintenance of spinal stability. The global muscle system consists of large and torque producing muscles that act on the trunk and spine without being directly attached to it. These muscles include the rectus abdominis, external oblique, and the thoracic part of lumbar iliocostalis.

They provide general trunk stabilization, but they are not capable of having direct segmental influence on the spine. The local muscle system consists of muscles that directly attach to the lumbar vertebrae and are responsible for providing segmental stability and directly controlling the lumbar segments. By definition, the lumbar multifidus, transverse abdominis, and posterior fibers of the internal oblique form part of this local muscle system. Therefore, if the basic morphology of the lumbar spine is compromised as in the case with symptomatic spondylolysis and spondylolisthesis, the neuromuscular system may be trained to compensate and to provide dynamic stability to the spine during the demands of daily living.

The co-contraction of the deep abdominal muscles with the lumbar multifidus has the potential to provide a dynamic corset for the lumbar spine enhancing its segmental stability during functional tasks and the maintenance of neutral spinal postures. O'Sullivan and his associates (1997) and Hides (1996) showed disagreement in pain score. Panjabi (1992) stated that there was significant difference between the specific exercise group and control group on the basis of functional disability level. However, Hides (1996) concluded that disability analysis over time was not significantly different between groups. Both studies only compared the effect of medical treatment and specific exercise groups. Both studies had only two treatment group. Control group received medical treatment, and experimental group received specific stabilizing exercise. Both studies did not have true control group (no medical treatment group). So, it is hard to see the true effect of spinal stabilization exercise. Study limitations included a biased selection process because of too strict inclusion criteria.

Specific exercises directed at the local muscle system have been advocated by physical therapists as an effective means of treating chronic low back pain conditions by enhancing the dynamic stability of the lumbar spine (Richardson and Jully, 1995). Recently, Hides and his associates (1996) carried out a randomized controlled trial in a group of subjects after their segmental loss of lumbar multifidus at the symptomatic level was detected by ultrasonography. Intervention group patients were treated with specific exercises similar to that carried out in O'Sullivan's study, while control group subjects received medical treatment.

At follow-up after one year, patients in the exercise group reported a significant reduction in pain recurrence when compared with control subjects. The specific exercise approach used in O'Sullivan and Hides studies was very different from general exercise approaches commonly advocated in the rehabilitation of patients with chronic low back pain. This approach was aimed to specifically train the isometric co-contraction of the deep abdominal muscles and lumbar mutlifidus with minimal co-activation of global system muscles. Once this pattern of co-contraction was achieved, it was immediately incorporated into static postures (such as sitting, standing, and sustained flexion), functional activities (such as bending, twisting, and lifting), and aerobic activities (such as walking, swimming, or running).

A challenge for further research will be to further investigate the potentials of this form of exercise intervention to alter automatic patterns of muscle recruitment within the trunk musculature in low back pain population. More research is needed to understand the nature of these motor-control problems in the deep muscles in patients with low back pain and particularly their implications for persistent and recurrent low back pain. Further clinical studies need to be undertaken to test the effectiveness of the specific stabilization program.

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