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Review Article

Effectiveness of Strengthening Exercises on Function and Pain in Adults with Low Back Pain - A Systemic Review and Meta-Analysis

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Abstract

The aim of this systematic review is to evaluate the effectiveness of strengthening exercises on improving strength, pain, and function in adults with low back pain. Methods: We only took in to account the randomized controlled trials (RCTs) on chronic low back pain (CLBP) where experimental group was compared with alternative therapy/control group. We compared mean and standard deviation or percentage changes between two groups for post-treatment and follow-up measurements. Results: The literature search found 14 RCTs, three of which were excluded because one was a prospective cohort study and the other two studies did not clearly report the treatment. The 11 RCTs finally included into the review applied the trunk strengthening exercises in CLBP. Results indicated that trunk-strengthening exercises decreased pain, improved strength, and function. Conclusion: The main findings from this systematic review of 11 studies showed that some patients in some studies who received trunk-strengthening exercises improved in pain, function, and strength more than those who received no treatment and alternative treatment.

Keywords: chronic low back pain; Strengthening Exercises; trunk-strengthening exercises

Abbreviations

RCTs: Randomized Controlled Trials; CLBP: Chronic Low Back Pain; ;LBP: Low Back Pain; ICF: International Classification of Functioning, Disability, and Health; NSAIDs: Nonsteroidal Anti-Inflammatory Drugs

Introduction

Low back pain (LBP) is one of the most common symptoms encountered in clinical practice. LBP predominantly accompanies musculoskeletal disorders or disorders related to the lumbar vertebrae and its associated soft tissue structures like muscles, ligaments, nerves and intervertebral discs. LBP deserves special attention when considering orthopedic impairments because its overall incidence is high and eventually it restrains the activities of daily living, decreases endurance, and diminishes quality of life. "Pain in the lumbosacral region of the spine, which spans the space between the first lumbar and first sacral vertebrae, is referred to as low back pain. The lordotic curve develops here in the spinal column. The fourth and fifth lumbar segments are the most commonly affected by low back pain" [1]. LBP defined as acute, subacute, and chronic. "An episode of pain that lasts shorter than three months is referred to as acute pain. It isn't related to the intensity or kind of the pain" [2]. "An episode of pain that lasts longer than five weeks but less than three months is referred to as sub-acute pain." [3]. "Chronic pain is defined as an episode of pain that has persisted for longer than three months" [4].

LBP is a major cause of disablement in many western countries. LBP is a growing epidemic in the United States. According to estimates, 7% to 10% of patients who develop LBP account for 70% to 80% of the costs for work-related low back claims [5]. Annual costs of low back disability in the United States have been estimated to be approximately $50 billion, with an average cost of a single case of work-related back pain exceeding $8,000. Its prevalence also appears to be on the rise, as 31.8% of disability claims in 1990 were due to back pain, compared to 29.2% in 1981 [5]. The cost for health care in the USA on LBP is approximately 20-50 billion per year.

The usual onset of LBP is seen in the third decade of life, with the peak prevalence during the fifth decade. The most common risk factors for LBP include smoking, obesity, psychological and psycho-

social factors. In addition, occupational factors are also associated with an increased risk of developing acute LBP or delayed recovery includes, unpleasant or noisy work environment and perception of poor social support in the work environment. Around 80 to 90% of patients show episodes of acute LBP which recovers in about 6 weeks, regardless of the administration or type of treatment. The rate of recurrence after an acute LBP episode ranges from 40% to 85% [6]. The most common orthopedic disorders associated with LBP are herniated disc, osteoarthritis, spondylolysis, spondylolisthesis, spinal stenosis, fractures, and spinal deformities. Musculoskeletal causes of LBP include overusing of muscles, ligaments, facet joints, muscle weakness, and the sacroiliac joint strain.

Secondary symptoms of back pain include bowel and bladder dysfunction, progressive weakness in the legs, fever, unexplained weight loss, stiffness, tightness, radiating pain to the buttock, thigh ,leg and muscle spasm, depression, anxiety, sleeplessness and spinal muscular deconditioning [7].

Anatomy

The anatomy of the low back is complex and it includes various structures such as vertebrae, muscles, ligaments, spinal cord, muscles, ligaments, nerves, and intervertebral discs. All these structures are meticulously aligned to provide both controlled mobilization and stabilization to the spine. The spinal cord and nerves are like electrical cables, which travel through a central canal from lumbar vertebrae into the legs, which produce radiating symptoms when the nerve compresses. The lumbo-sacral junction is one of the important functional units of the human body; it includes five lumbar vertebrae and the sacrum. The lumbar vertebrae are structurally large and massive in nature and they are specifically designed to carry most of the body weight [8].

Biomechanics

The biomechanics of the lumbar spine includes stability and mobility of the lumbar region by providing support for weight of the upper part of the body. The lumbar structures are better able to withstand the extra weight since the lumbar vertebral bodies and discs are larger than those in other areas. The anterior longitudinal ligament, which is well developed in the lumbar area, helps to support the anterior portion of lumbar vertebrae and discs. The abdominal muscles helps to prevent the excessive lumbar curve by exerting a pull on the pelvis but when these muscles contract, they create compressive forces on the structures of the lumbar region. A specific instance of coordinated activity of the lumbar flexion and anterior tilting of the pelvis in the Sagittal plane is called lumbar pelvic rhythm [8].

The structures of the spine are compressed and strained as a result of lumbar flexion. While the posterior tissues are under stress in forward flexion, the anterior structures including the disc's anterior location and the anterior ligaments and muscles are compressed. Collagen fibres in the posterior annulus fibrosus, zygapophyseal joint capsule, and posterior ligament resist the tensile pressures, limiting the range of motion and promoting stability in flexion [8].

In lumbar extension, posterior structures are compressed while anterior structures are subjected to tension. Resistance to extension is provided by anterior fibers of annulus fibrosus, joint capsule, and anterior ligament.

There are several of types of pain in adults with LBP. These include localized pain is where the patient will feel soreness or discomfort when we palpate on a specific area of tenderness [6]; diffuse pain can spread over a larger area and comes from deep tissue layers of the skeletal muscles, radicular pain is caused by irritation of a nerve root or nerve inflammation characterized by sharp, shooting and stabbing pain along the sciatic nerve secondary to a herniated disc. Sciatica is one of the best examples of radicular pain, referred pain will be perceived in the lower back caused by inflammation, irritation, nerve compression and disc prolapsed [9]. It is also produced by radiating and stabbing pain symptoms from kidneys or lower abdomen. The mechanism behind referred pain mainly involves both peripheral and central nervous system pathology.

The underlying etiology of low back pain will involve peripheral nervous system, central nervous system or an imbalance among the two [10]. Weak muscles are often the root cause of back pain, especially lower back muscles, mainly back extensors, abdominals, gluteus and hip flexors which act as core muscles of the spine [11].

With normal aging, cracks or fissures in the nucleus pulpous and annulus might be the source of back pain. If the fissure extends out of the disc, material from the disc may push out or come apart, this often referred to as a herniated or slipped disc. If the protruded disc compresses a nerve, it may cause pain in the leg. Unrelenting or chronic pain can persist for years and even decades after the initial injury, which is resistant to multiple treatment modalities.

A standard examination of the lumbar spine involves both subjective and objective evaluation. Subjective evaluations include history taking and visual analog scale; objective examination may include standard low back pain scales like Oswestry Back Pain Dis-

ability Questionnaire and Quebec Back Pain Disability Scale. This kind of approach will be useful for the therapist to find out the areas of paraesthsia, anesthesia and distribution of pain.

Treatment for LBP

Patients with back pain need to return to normal activities as soon as possible but are often afraid of movement or activity that may be harmful. The major goal of exercise therapy for patients with LBP is to teach the correct posture, strengthen the weak muscles, and prevent pain while normalizing the spinal movement patterns during work and other activities (O'Sullivan and Schmitz, 2001). Exercise therapy has been shown to be effective in patients with chronic low back pain in strengthening of the spinal muscles. By strengthening of back and abdominal muscles, it will help to maintain good posture, keep the spine in correct position, and act as defense mechanism against gravity.

Complementary treatment

There are several other complementary and alternative treatments are available to relieve back pain. Of those most common alternative treatments are Acupuncture, Massage therapy, Cognitive-Behavioral therapy, Spinal manipulation, Exercise therapy, Drug therapy, Electrical stimulation, Transcutaneous electrical nerve stimulation, Interferential current therapy, Ultra Sound, Yoga and Tai-chi [11].

Exercise therapy.

Exercise is any programme that requires patients to perform repeated voluntary dynamic movements or static muscle contractions (in either case, either "whole-body" or "region-specific," and either with or without external loading) during therapeutic sessions. Exercise therapy is one of the important components in treatment of chronic low back pain. Mainly the back muscles may become weak and atrophied through disuse [12] and lead to deconditioning, which than may contribute to disability. Although it is difficult to tell whether decreased muscle strength among patients with chronic pain is a cause or a consequence of their pain [12], several studies have suggested that decreased strength in the abdominal and spine extensor musculature is associated with the recurrence of persistence of low back pain [13]. Diminished cardiovascular fitness has also been found to be associated with a higher incidence of back pain disability as well as more frequent episodes of low back pain. McKenzie exercise method is widely considered to be a highly effective exercise program for patients with chronic low back pain. The main concept behind the McKenzie exercise is mainly focused on core muscle contraction as well as stabilization of the trunk and extension of the spine. It usually involves series of active and passive trunk flexion, extension, and combination of side bending and rotations. McKenzie exercises mainly helpful in "centralizing" of pain [14].

Drug therapy

Drug therapy can alleviate pain symptoms, but they typically don't change the underlying physiologic causes of pain [15]. However, medication is frequently administered to CBP patients despite the fact that there are very few standardised guidelines pertaining to the kind of medications that should be administered for particular pain problems. Nonsteroidal anti-inflammatory drugs (NSAIDs) are frequently used to treat CBP, and as a group appear to be superior to placebo and have moderate treatment efficacy. However, these medications have been found to have little effect on pain due to sciatica [15]. Deyo reported that muscle relaxants also appear to be superior to placebo for treating low back pain, but their effectiveness for treating CBP pain has rarely been studied. Their mechanism of action is generally unknown.

Special consideration may need to be given to patients with both LBP and depression. This is important as the analgesic effects of the tricyclic antidepressants are produced at dosage levels approximately one fifth to one third of the dosages recommended for effective treatment of depression [16]. The efficacy of various dosages of antidepressants in chronic pain patients, or combinations of antidepressants, deserves further study as a large proportion of patients with chronic pain also suffer from depression [17].

Clinicians should have an idea which treatment will reduce pain and improve function in LBP. The main aim of this study is to systematically review and synthesize information from published articles that have studied the effects of flexion and extension exercises on reducing pain and improving functional outcome compared to other therapeutic interventions for adults with LBP. If back strengthening exercises are shown to be more effective when compared to other interventions, and then physical therapists will have new information which will enable those to make evidence based decisions for treating patients with low back pain. By enhancing stability and strength around the stressed back structures, strengthening exercises may help those with chronic back pain. Strengthening exercises are tailored specifically to the patient and the type of back pain being addressed, and also help to avoid deconditioning that result from decreased activity.

This proposed research paper will review the evidence investigating back strengthening exercises for relieving back pain, increasing the range of motion and improving the functional capability to participate in daily life tasks in those with chronic low back pain.

Literature Review

To determine the amount of evidence on strengthening exercise programs for patients with low back pain, a review of literature

was conducted. The review revealed that there were 35 RCTs, 10 non RCTS, and 5 case studies. Important reviews included a systematic review of exercise therapy for treatment of non-specific low back pain and a study on strategies for using exercise therapy to improve outcome in chronic low back pain. Most of the studies compared the exercise therapy to other alternative treatments TENS, laser therapy, manipulation, standard exercise, motor control exercise, and McKenzie extension exercises for treating chronic low back pain. Most of the studies used resistance exercises to strengthen the lumbar extensors and lumbar flexors. For this study, back strengthening exercises will be defined as active, passive, isometric, isotonic, resistance exercises to flexors and extensors of the spine.

Materials and Methods

Research question

The research question for this systematic review is: what is the effectiveness of strengthening exercises on improving strength, function and pain in adults with low back pain?

Design

This study used systematic review and meta-analysis methodology.

Acquiring articles

A variety of electronic databases were searched including: Cumulative Index to Nursing and Allied Health Literature (CINAHL); MEDLINE; Cochrane Library; PubMed; PEDro; and PubMed central. The references from the found articles were also searched to locate the articles. Key terms used (Low back ache OR chronic low back pain OR backache) AND (physical therapy OR exercise therapy for reducing pain OR Lumbar extension strength training OR flexibility exercises OR trunk stabilization exercises OR flexion exercises) AND adults with chronic back pain.

Inclusion/exclusion criteria

The inclusion criteria were: 1) studies with RCT design; 2) articles published from 1990 to 2009; 3) articles studying the effectiveness of exercise, either strengthening of lumbar extensors or flexors or in combination of both; 4) Outcomes measured in the study include body impairments (muscle strength, pain and, function), activity limitation (difficulty in the activities of daily living), and International Classification of Functioning, Disability, and Health (ICF) definition of participation restriction; 5) studies comparing the effects of lumbar strengthening to other interventions including physical agents, TENS, manipulative therapy and yoga. Exclusion criteria for this study included: 1) articles studying the effects of core strengthening, hydrotherapy on chronic low back pain; 2) articles not including the outcomes as mentioned in our study; 3) studies done before 1990; 4) non-RCT studies.

Procedure of review

All qualified and appropriate studies were obtained in full text and entered based on the inclusion and exclusion criteria. Each article was studied individually followed by the discussion between three reviewers and differences were resolved by group discussion. The purpose of the discussion was to extract the relevant information from the articles to make subjective decisions about quality rating (internal validity) and clinical importance. Internal validity ratings of articles were done by using the Physiotherapy Evidence Database (PEDro) scale (see Appendix 4). The results were placed into narrative and evidence tables by using American Academy for Cerebral Palsy and Developmental Medicine (AACPDM) format (see Appendix 1).

Results and Discussion

Study characteristics

The literature search resulted in the identification of 14 studies concerning the effectiveness of strengthening exercises on pain, strength, and function in adults with chronic low back pain. Of the 14 studies, 11 were included in this systematic review and three studies (18), were excluded as one was a prospective cohort study and the other two studies did not clearly report the treatment. All 11 studies included in this systematic review were RCT with level of evidence (LOE). These studies were rated according to the PEDro scale and had strong internal validity.

In this review, there was high variability from study to study in terms of participant characteristics, treatment techniques and treatment duration, intensity and frequency. Participants in all these studies were diagnosed with chronic low back pain between the ages of 18-60 years old. In this systematic review, the studies with subjects diagnosed with specific pathologic entities such as, infection, neoplasm, metastasis, osteoporosis, and rheumatoid arthritis were excluded; see table 1 for a description of study characteristics.

The type of trunk strengthening across these studies varied from extension in isolation, to combined flexion and extension, to isometric, isotonic, and isokinetic exercises. In addition to these exercises, therapeutic modalities like TENS were also used in comparison to trunk strengthening exercises. Seven studies combined flexion and extension exercises [19-25], and three studies used lumbar extension only [26-28]. Another study was a follow-up study of Petersen., *et al*. (2002). Most of the studies reported 30 to 60 minutes of exercise intensity, frequency of 1 to 3 sessions per week and duration of 2 to 10 weeks.

Among the 11 studies in this review, two studies [25,29]. compared trunk strengthening with placebo or no treatment. Nine studies Akbari., *et al*., 2008; Browder., *et al*., 2007; Goldby., *et al*., 2006; Kofotolis., *et al*., 2008; Koumantakis., *et al*., 2005; Long., *et al*., 2004; Petersen., *et al*., 2002; Petersen., *et al*., 2007; Schenk., *et al*., 2003 compared trunk strengthening with a control group. The control groups in these nine studies included the following alternative treatment techniques: joint mobilization, spinal manipulation, educational booklet, and TENS.

In this review of studies, pain was the most commonly measured outcome. However this review also revealed a wide range of methods for measuring pain. These methods can be described within three main categories: 1) Quantitative measure that measured pain at rest using numeric scales such as the VAS (see Figures 2 and 3); 2) Qualitative measures that describe the nature of pain such as West Haven Multi-dimensional Pain Rating Scale; and 3) Functional pain that measured the effects of treatment on pain during functional movement with tools such as the Roland Disability Questionnaire and the Oswestry Disability Questionnaire (see Figure 4).

Most of the outcomes in this review investigated the impairment of body structure/body function dimension of ICF. There was less information on the outcomes that come under activity limitation and participation restriction dimensions of the ICF. The most frequently used outcomes in this review were quantitative pain rating scales and this included the Aberdeen Pain Rating Scale, Visual Analog Scale, Manniche's Low Back Pain Rating Scale, NPRS, McGill Pain Questionnaire, Oswetry Disability Scale; one study utilized the West Haven Multi-dimensional Pain Rating Scale, which was a qualitative pain rating scale. Five studies utilized functional pain measures including the Oswestry Disability Scale, Roland Disability Questionnaire, Oswestry Disability Questionnaire.

Main findings

Trunk strengthening versus no treatment (qualitative and quantitative pain scales)

Pain. Overall, patients who received trunk strengthening experienced significantly greater pain reduction than those who received placebo or no treatment. Pain measured by the Aberdeen Back Pain Scale in Moffett., *et al*. (1999), and West Haven Yale Multidimensional Pain Inventory in Risch., *et al*. (1993) showed the trunk strengthening group improved significantly more than the control group. The effect sizes for Moffett., *et al.* (1999) and Risch., *et al*. (1993) were small (d = .201) and large (d = 0.829) respectively suggesting a large difference in the magnitude of pain reduction between groups in these studies. The overall effect size for both studies was d = 0.337, see figure 1.

Figure 1

Strength. In Risch., *et al*. (1993), strength was measured at seven joint angles with the MedX lumbar extension machine, and the trunk strengthening group showed statistically significantly more improvement ($p < 0.01$) than the control group after 10 weeks duration. Moffett., *et al*. (1999) did not measured strength outcome.

Pain during movement. In Moffett., *et al*. (1999), the Roland Disability Questionnaire measured pain during functional movement in all groups. The trunk strengthening group showed greater improvement in function when compared to control group ($p = 0.06$).

Trunk strengthening versus alternative treatment (quantitative pain scale)

Pain. In this review, there was high variability from study to study in the way pain was measured; all three forms of pain measures were represented in studies comparing trunk strengthening

to alternative treatments. Across the eight studies comparing trunk strengthening versus alternative treatment, 4 studies showed trunk strengthening was significantly better than the alternative treatment, whereas the other 4 studies revealed no difference between the groups. However, eight studies in the follow-up period showed the trunk strengthening group was statistically significant when compared to alternative treatment. In Petersen., *et al*. (2002), there was no statistically significant difference between trunk strengthening group and alternative treatment group, but the amount of pain reduction between these two groups was statistically significant during the 2 months follow-up period. In Schenk., *et al*. (2003), there was a statistically significant difference between the two groups with $p < .04$. In Koumantakis., *et al*. (2005) there was no statistically significant improvement between groups ($p > 0.5$), this showed that both groups had achieved similar change over time. In Goldby., *et al*. (2006) and Browder., *et al*. (2007) both groups showed substantial reduction in pain, but there was no statically significant difference between groups. In Akbari., *et al*. (2008) and Kofotolis., *et al*. (2008) there was a statically significant reduction between groups with $p < 0.05$. The overall effect size for all these studies was small ($d = 0.307$) see figure 2.

Figure 2

The most frequently used outcomes in this review were quantitative pain rating scales. Figure 3 shows a forest plot with those studies that used quantitative pain scales and includes studies comparing trunk strengthening to nothing (control group) or an alternative treatment. The overall effect size for the quantitative pain outcome was very small ($d = 0.241$ and $p = 0.01$), see figure 3. There was large variability in the effect sizes across these studies because of high variability in measuring pain outcomes by using different pain scales and large difference in the treatment duration, intensity and frequency.

Trunk strengthening versus alternative treatment (pain during movement-function)

Pain during movement. In those studies that attempted to measure the activity limitation dimension of the ICF (Goldby., *et al*., 2006; Kofotolis., *et al*., 2008; Koumantakis., *et al*., 2005; Long., *et al*., 2004; Petersen., *et al*., 2002) the findings showed no statistically significant difference in trunk strengthening exercise group when compared to alternative treatment immediately after treatment and the overall effect size was small ($d = 0.126$), see Figure 4. However, four studies (Goldby., *et al*., 2006; Koumantakis., *et al*., 2005; Long., *et al*., 2004; Petersen., *et al*., 2002) showed a significant improvement at the follow-up period in trunk strengthening exercise group. Overall pain during movement scores showed no significant improvement during immediate treatment period in the trunk strengthening exercise group when compared to alternative treatment group ($p > 0.124$ and $d = 0.126$). Nevertheless, the differences were statistically significant in the follow-up period.

Discussion

Trunk strengthening versus no treatment

The first main finding from this systematic review of 11 studies showed that patients who received trunk-strengthening exercises improved in pain, function, and strength more than those who received no treatment. However, the overall effect was small suggesting that the amount of pain reduction in patients who received trunk strengthening was only slightly greater than those who received no treatment. This finding may be explained by the fact that

Figure 3

Figure 4

the type of treatment and treatment parameters across the studies varied greatly. Studies with low frequency (2-3 times/week) and duration (3-4 weeks) had a smaller effect than studies with a high frequency (3-6 times/week) and duration (8-10 weeks). In addition, there was a large variability in patient diagnosis and the way the pain was measured. Therefore this high variability in individual study effect sizes may explain why the overall pooled effect size was small.

This meta-analysis found evidence that trunk strengthening was effective in reducing the pain but the overall effect size was small when compared to no treatment in chronic low back pain. This finding is consistent with a previously published systematic review and meta-analysis that also showed a small treatment effect for trunk strengthening compared to control in patients with chronic back pain (Hayden., *et al*., 2004).

Trunk strengthening exercises vs alternative treatment

The second main finding from this systematic review showed that the majority of patients who received trunk strengthening exercises experienced no greater improvement in pain reduction when compared to patients who received alternative therapies (joint mobilization, spinal manipulation, educational booklet, and TENS) for pain during rest. The overall effect size was small (d = 0.307). There was large variability in the effect size across the studies, which may be explained by the fact that a wide variety of pain measures were used and there was a large difference in the treatment duration, intensity and frequency across these studies. However, in two studies (Akbari., *et al*., 2008; Long., *et al*., 2004) the trunk strengthening group showed significant improvement in pain reduction as compared to alternative treatments because exercise training was specifically designed to strengthen deep trunk muscles alone before progressing to strengthen the superficial trunk muscles. However, six studies showed trunk strengthening exercises had no significant improvement when compared to alternative treatment with overall small effect size. This finding may be explained by the fact that there was a large difference in the treatment duration, intensity, and frequency across these studies.

The third main finding from this review revealed patients who received trunk strengthening exercises showed no significant improvement in pain reduction during movement (function) when compared to the alternative treatments after initial treatment phase. The overall effect size was very small (d = 0.126). This suggests that the trunk strengthening exercise was equally as effective as alternative treatment, which may be explained by the fact that large differences in measuring pain and treatment parameters. Nevertheless, the overall findings across these studies revealed that trunk strengthening exercises showed greater improvement in follow-up period due to more frequency (3-6 times/week) and duration (8-10 weeks).

On the whole, the overall improvements in these outcomes across these studies were small. But the trunk strengthening exercises showed slight improvement when compared to no treatment and alternative treatments. This suggests that the trunk strengthening was as effective as other alternative treatments.

Conclusion

This systematic review and meta–analysis of 11 studies provided evidence that trunk strengthening exercises showed slightly greater improvement on pain, strength and function in adults with chronic low back pain than no treatment. However, the magnitude of the differences between treatment and control across all the studies was small. There was no clear benefit for trunk strengthening exercise when compared with alternative treatments. In the long-term, the trunk strengthening exercises were more effective in reducing pain at rest and during movement than control and alternative treatments. There was large variability in treatment protocols and methods for measuring pain across studies in this review suggesting that rehabilitation for patients with low back pain lacks consistency. It also shows that there is no one type of exercise that clearly outperforms the others for patients with nonspecific low back pain. More research is needed to clarify the effectiveness of strengthening exercise on various forms of pain in adults with low back pain.

Limitations

In this review, only the pain outcome was measured in most of the studies. This limits the ability to report other important outcomes related to activity limitation and participation restriction. The lack of consistency in measuring these outcomes was disappointing. Another limitation was the large heterogeneity in terms of participant characteristics, treatment techniques and treatment parameters. However, from this review it was still unclear which type of trunk strengthening (flexion, extension or combined flexion and extension) was more effective. Also, it was unclear how much intensity, frequency, and duration of trunk strengthening is required to improve pain, strength and function.

Suggestions for Future Research

Further investigation should focus on the effectiveness of strengthening exercises in adults with chronic low back pain by using a large sample size and specific exercise parameters (intensity 45- 60 minutes, frequency 4-6 times/week and duration 8-12 weeks). Future RCTs should maintain the homogeneity and provide

the type of treatment and treatment parameters across the studies varied greatly. Studies with low frequency (2-3 times/week) and duration (3-4 weeks) had a smaller effect than studies with a high frequency (3-6 times/week) and duration (8-10 weeks). In addition, there was a large variability in patient diagnosis and the way the pain was measured. Therefore this high variability in individual study effect sizes may explain why the overall pooled effect size was small.

This meta-analysis found evidence that trunk strengthening was effective in reducing the pain but the overall effect size was small when compared to no treatment in chronic low back pain. This finding is consistent with a previously published systematic

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