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The Effectiveness of Stabilization Exercises in Treating Patients with Chronic Low Back Pain: A Systematic Review

Sultan A. Alzubeidi[1*], Abdurrahman A. Alfawaz[2], Mohammad Y. Algharawi[1], Abdulrhman S. Alrashidi[1], Marwan A. Alamrani[1], Ali B. Alsayed[1]

Sultan Abdullah Alzubeidi, Senior Physiotherapist, Email sultanalzubeidi@hotmail.com

Abdurrahman A. Alfawaz, Senior Physiotherapist, Email alfawaz123@gmail.com

Mohammad Yahya Algharawi, Senior Physiotherapist, Email al_gharawi@hotmail.com

Abdullrahman Saeed Alrashidi, Physiotherapist, Email Aboazoz26306@gmail.com

Marwan Ahmad Alamrani, Senior Physiotherapist, Email marwanalamrani@gmail.com

Ali Baalqasim Alsayed, Physiyotherapist, Email Alialsayed24@gmail.com

[1]King Salman Armed Forces Hospital, Tabuk, Saudi Arabia.

[2]Center and School of Medical Services for armed forces, Saudi Arabia

ABSTRACT

Background: Chronic low back pain is one of the biggest health problems around the world. It is considered as one of the main causes of disability, high medical expenses and absenteeism. Chronic low back pain can be treated indifferent ways. However, the efficacy of most of these treatments has not been studied so medical intervention for chronic low back pain varies widely. Stabilization exercise is one form of physiotherapy treatment recommended in some guidelines. However, there is an argument about the effectiveness of this intervention.

Objective: This systematic review aimed to investigate the effectiveness of stabilization exercises on patients with chronic low back pain and disability.

Study Design: Systematic Review.

Search Strategy: An online research through the electronic databases, such as Ovid, Medline, CINHAL, Google Scholar, Cochrane library, Pedro database and Pub med was conducted. Citation searches within studies, as well as online tracking of references were also conducted in this review.

Mean of Analysis: The Pedro scale was used to assess the quality of the included randomized controlled trials, where studies which scored equal to or more than 5/10 were considered as a high quality studies. In addition, a simple qualitative analysis was performed to analyze data and give accurate results.

Main Results: Twenty studies met the inclusion criteria. Seventeen studies were randomized controlled studies; one was a study case series, one a cohort study, and one a comparative study. The most outcome measures among the studies were pain (numerical pain rating scale, visual analogue scale and short-form McGill pain scale) and disability (Ronald & Morris disability questionnaire and Oswestry disability questionnaire). The results show significant changes between the studies in terms of pain and disability. However, there is moderate evidence about effectiveness of the stabilization exercises for long term sufferers (>6 months).

Conclusion: Using stabilization exercises on patients with chronic low back pain is helpful to

reduce pain and disability. However, there is no preference for this intervention over other physiotherapy interventions.
Recommendation: High quality studies are needed to investigate the efficacy of this intervention for long term.

Keywords: Lumbar stabilization exercises; core stability exercises; motor control exercises; chronic low back pain.

1. INTRODUCTION

Chronic low back pain is one of the largest health problems around the world. It is considered as one of the main causes of disability, high medical expenses and absenteeism (Van Tudler et al., 1995). Chronic low back pain can be treated indifferent ways. However, the efficacy of most of these treatments has not been studied. As such, the medical intervention for chronic low back pain varies widely (Van Tudler et al., 2000). The aim of this systematic review is to investigate the effectiveness of stabilization exercises on treating patients with chronic low back pain.
Chronic low back pain is one of the most common problems facing primary care doctors in the developed and developing world. It can be said that it is the major musculoskeletal disorder in those visiting GPs (Chew-Graham and May, 1999). It is described as pain, spasm, or difficulty of movement affecting the area between the costal edge and the lower gluteal fold, with or without lower limbs pain (Koes et al, 2006). There is another definition for the chronic low back pain, the pain located in the lumbar region and radiated to the legs (Fauci et al, 2008). The term 'chronic' refers to pain that has been present for more than twelve weeks or three months (Liddle, 2004; Rathmell, 2008). The major considerable symptoms of chronic low back pain might be summarized as pain and disability.
Chronic low back pain is widely spread in workplaces, especially among those aged between 25-24 years, which is reflected passively on the medical costs. Chronic low back pain was classified as one of the five main causes for people to seek medical care in the U.S. Fifteen million visits to GPs because of low back pain were reported in 2008 (Rathmell, 2008). In 1995, annual expenditure on low back pain in the U.S. was estimated at$8.8 dollars (Borne stein, 2000). However, in the UK the total cost of managing low back pain every year ranged between £265 million and £338 million

(NHS Centre for Reviews and Dissemination, 2000). It has been observed that most of this was in the form of payments for diagnosis procedures, physiotherapy, and surgery (Bornestein, 2000).

Although more than 75% of chronic low back pain cases have known causes or nonspecific etiology (Chew, Graham &May, 1999), it has been conceded that the lumbar instability is one of the primary causes of chronic low back pain (McGill, 1998; O'Sullivan et al., 2000). The trunk muscle contractions work as a primary stabilizer of the lumbar spine (McGill, 1998). This explains the role of the stabilization exercises in supporting the mobility of the lumbar spine.

Spinal instability has been defined in many different forms. For example, "the lax region around the neutral zone which is the neutral position of a segment of the spine" was coined by (Panjabi, 1992 p.391). According to O'Sullivan et al., 2000, "The neutral zone was found to be greater with intervertebral disc degeneration and intersegment injury and found to be decreased with stimulated muscle forces across a motion segment". Spinal stability is directly affected by interactions between muscles, ligaments, tendons, and the central nervous system (CNS) (Appendix 3). However, the increment in the neutral zone leads to increments in spinal stability (O'Sullivan et al., 2000). Segmental spinal instability is a protection process of the entire spinal stability system, to: (i) preserve the physiological limits of the neutral zones between the vertebrae; (ii) avoid further neural dysfunction; and (iii) minimize the intensity of pain (Pinjabi, 1992).

The trunk's muscular system is classified to three main categories:(i) muscles which are responsible for local spinal stabilization; (ii) others responsible for global stabilization; and (iii) muscles of global mobilization (Comeford & Mottram, 2001) (Appendix 4). The global stabilizer system consists of large muscles (oblique abdominis externus, rectus abdominis, lumbar ilicostalis (thoracic part)), which have the efficiency to produce a massive torque on the trunk. Although these muscles have no direct attachment to the spine, they contribute to the stabilization process (O'Sullivan et al., 2000). In contrast, the local stabilizer muscles have a direct attachment to the spine which works as a segmental spine stability, as well as lumbar

mobility controller. These muscles include: lumbar multifidus, transversus abdominis, longissimus, quadratus lumborum, diaphragm, ilocostalis (lumbar part), psoas major, and the posterior fibers of the oblique abdominis internus (O'Sullivan et al., 2000).

The spinal stability system might be affected the most in the neutral zone in case of weakness of the stabilizer muscles, even though with a small load (Cholewicke & McGill, 1996). In other words, when the stabilizer muscles are weak, the lumbar spines are at high risk of instability. In this case, lumbar spines try to maintain their stability by hyper activation or stiffness of the local stabilizer muscles. This mechanical stability is preserved by the coordination recruitment of the muscles between the global stabilizer and local stabilizer.

Over the last forty years, physiotherapists for the active treatment of chronic low back pain have used stabilization exercises. These exercises have proved their efficiency in regaining spinal stability after injuries, degenerative changes, or any other spinal stability disturbances (Knudsen, 2001). In addition, it has been concluded that patients who are treated by stabilization exercises are twelve times less likely to have pain recurrence in the first three years after intervention than those who were not treated with these exercises (Knudsen, 2001).

Inappropriate contraction of the one of the global or local stabilizer muscles might lead to spinal instability, because the trunk muscles are working concurrently. Therefore, any disturbance in this mechanical process might lead to instability (McGill, 1999). The conception of stabilization exercises is highly correlated with the relationship between chronic low back pain and lumbar instability, and even with the relationship between muscle balance disturbance and low back pain.

The stabilization exercises program was developed after the initial recommendations of Hodges et al. (1996) and O'Sullivan et al. (1997). It consists of twelve sessions, where the first session is used only for assessment and the last session for discharge. The other ten sessions are the sessions in which the stabilization exercises are performed. Depending on the pre-program assessment, each patient will be prescribed specific stabilization exercises. All the exercises seek to support the function of the trunk muscles that are responsible for spinal stability. These exercises should mainly aim at the transverses abdominis and multifidus.

Overall, it has been argued that the physiotherapy treatments aimed to restore the

normal activity of the trunk muscles, lead to reduction of pain and functional disability. Hence, this systematic review was conducted and aimed to investigate the effectiveness of stabilization exercises on patients with chronic low back pain.

2. SEARCH STRATEGY

2.1 Selection of studies

Arius studies have been chosen with different levels of quality, including systematic reviews, randomized controlled trial, case series, cohort studies, comparative studies, and observational studies. Several opinions have been chosen from both published and unpublished studies in order to conduct a comprehensive conclusion.

2.2 Sources of material

2.2.1 Electronic search

The most popular physical therapy and manual therapy databases were searched, and suitable articles were selected. These databases included: Pub med, AMED, Ovid, Medline, Pedro, Google Scholar, CIHAL and Cochrane library. EBSCO (Medline and CINHAL), Pedro website, and Cochrane library were searched thoroughly. Automatic alert was used to keep up dated with new publishing.

2.2.2 Other sources

Some studies were collected from other sources, such as citation searching within the studies; following references through the internet, especially into SCOPUS, CINHAL databases; and others from chronic low back pain websites.

2.3 Search terms

The PICO question has been used in order to help of structuring of this study design. Many terms were applied to find all related studies. These terms included keywords and Mesh terms. The terms were used are Stabili* exercises OR Stabili?ation exercises OR stabili?ation program OR motor control exercises OR spinal Stability exercises OR core stability OR transverses abdominis OR multifidus OR lumbar Stability

exercises AND low* back pain OR low* back ache OR low back instability OR lumbago

OR sacroiliac pain OR lumbo-sacral dysfunction OR sciatica OR disc herniation OR disc prolapse.

2.4 Searching strategies

Thoroughly searching in the above mentioned databases was followed in the period 15th of April 2013 to 5th of July 2013. By numbers and after removing of the duplicated studies in the different databases and search sources, 804 studies were found and numbers of fifteen articles were found from searching within these studies, which increase the first number to 819 studies. All these 819 studies were screened by checking every individual study title and skim-reading through the content. This screening process led to a decrease in the total number of studies to 41, because the reviewer observed that some studies were not related to the review questions; and some did not concur with the inclusion criteria. The scan reading of the 41 remaining articles led us to reduce this number to 20 studies, which fitted the inclusion criteria. Twenty studies were included to this review, while 21 studies were excluded as a result of unsuitability for the eligibility criteria.

2.5 Inclusion and exclusion criteria

2.5.1 Inclusion criteria

In this review the characteristics of the included studies are as follows:

*Adult participants aged between eighteen and sixty years, either male or female.

*Participants who diagnosed with chronic low back pain, for more than three months (twelve weeks) of symptoms.

*Studies conducted in the period 1996 to 2012. These dates were selected because of the initial development of the stabilization exercises (Hodges et al., 1996).

*Full copy of the must be available for screening.

* Study is conducted in English.

*The stabilization exercise is used as a primary intervention.

* The randomized controlled trials must compare the stabilization exercises with other active or inactive intervention.

* Outcome measures must investigate pain and disability in patients before and after the intervention.

All high and low quality papers have been included in this review.

2.5.2 Exclusion criteria

Any studies which stated that the patient had a serious pathology or red flag, such as spinal tumor, unstable spinal fracture, infection, or severe inflammatory condition were excluded from this review. Pregnant patients, or patients with congenital deformities, were also excluded. Studies which reported any neurological deficits were excluded. Studies that did not use pain and disability measures as a primary or secondary outcome measure; or included patients younger than eighteen or older than sixty years were also excluded.

2.6 The outcome measurement

In this review many types of outcome measures have been used to measure the pain and disability. They were categorized as primary or secondary outcome measures. The pain outcome measures include: (i) numerical pain rating scale; (ii) visual analogue scale; (iii) short- form McGill pain questionnaire. The disability outcome measure included: (i) Oswestry disability questionnaire; and (ii) Ronald & Morris disability questionnaire.

3. Literature Review

3.1. Overview

Twenty studies met the inclusion characteristics for this investigation of the

effectiveness of stabilization exercises in patients suffering from chronic low back pain for more than three months.

3.2 Methodology Quality

The risk of bias for the included randomized controlled trials:

The included randomized controlled trial (n=17) quality were measured using the PEDRO scale. Five studies scored 8/10, Four studies scored 7/10, One study scored 6/10, and Five studies scored 5/10. Two studies considered to be low quality. Of these, one scored 4/10; the other scored 3/10 (Table 3).

3.2.1. Population

All the studies selected participants who are over eighteen years old, except only one study which selected subjects more than thirty years old (Celestini et al., 2005). The mean for the ages is equal to 45.2. The majority of the participants were female with a percentage of (62.5%); the percentage of the male population was (37.5%). Six of the studies did not determine the gender of participants (Miller et al., 2005; Bakhitary et al., 2005; Cairns et al., 2006; You & Lee 2012; France et al., 2012; Kachanathu et al., 2012).

The duration of the symptoms (more than three months) of low back pain was one of the inclusion criteria in the vast majority of the studies. Only a few papers included subjects with shorter duration of symptoms, more than two months of symptoms (Bakhitary et al., 2005; Hick et al., 2005).

3.2.2 Techniques

Most of the studies used the stabilization exercises in the Richardson and Jull (1995) maneuver, which aimed to improve the segmental stability of the lumbar spine. This approach consists of two steps. Firstly, the subject taught how to perform a specific isometric contraction to the deep abdominal muscles without any contributed torque from the superficial muscles, such as external oblique muscle, rectus abdominis or internal oblique muscle, by using abdominal draw-in technique. Secondly, the subject taught how to perform the deep abdominal muscle contraction with co-activation of the lumbar muscles. The commencement of the two steps should be in low-load and non- functional positions (four-point kneeling, prone, supine, lying, and lying with knees in flexion). Any substitution movement from the breathing muscles while

performing these exercises should avoided. The subject should gradually reach up to ten contractions with ten second holds (Richardson and Jull, 1995). Once the subject is able to perform these contractions properly, the program will progress by applying leverage while the subject moves his or her limb. Asking the subject to do these exercises on a daily basis and enrolling them with daily activities is an important point in this approach, especially with pain proactive activities, because this will enhance stability during lumbar spine mobility (Richardson & Jull, 1995; O'Sullivan et al., 1997; Hodges, et al. 2003).

Celestini et al. applied the stabilization exercises intervention as transversus abdominis muscle retraining, either specific or with a group of superficial abdominal muscles, as well as the lumbar multifidus muscle. However, Norris and Mathews (2008) applied the integrated back stability exercises in three stages. The first stage is to put the subject in a hyperlorodtic position and move toward lumbar flexion, to increase the activation of the abdominal and hip extensor muscles and increase the length of the iliacus and psoas muscles. The second stage includes strengthening exercises, flexibility and endurance exercises. The third stage is to enroll these exercises with daily living activities.

Another study illustrated the stabilization exercises as isometric contractions for the trunk muscles, with the subject in a sitting position and the therapist gradually increasing pressure from minimal to maximal resistance to the trunk flexion and extension alternatively (Koftolis et al., 2008). A further study described the stabilization exercises with two movements: (i) handing-in, which means drawing in the abdominal muscles without movement in the low back segments with a holding time of ten seconds; and (ii) hand-knee, which means raising one of the upper extremities with the opposite one of the lower extremities, with a holding time of five seconds (Ota et al., 2011). One more study explicitly describes the technique as a stretching exercise to the trunk muscles, transversus abdominis and multifidus in particular (Child et al., 2004).

The two remaining studies did not explain how the stabilization exercises were performed (You &Lee, 2012; Lewis et al., 2005).

3.3 Effectiveness of the stabilization exercises on chronic low back pain

3.3.1 Intervention with stabilization exercises only

The participants studied by Ota et al. (2011), with a sample size (n= 18), were treated for three months with stabilization exercises. They conceded that there was an increasingly significant improvement up to six months in the visual analogue scale questionnaire from 49mm t0 6mm (p= 0.048). This improvement is not longer than six months. This study gives some evidence for using of this intervention.

3.3.2 Comparing stabilization exercises group with no intervention group

Three studies compared the intervention group exercises and the control group. Shaughnessy and Caulfield (2004) conducted a study that did not provide a concealment allocation and intention to treatment. They enrolled twenty subjects with chronic low back pain to the study who were treated for ten weeks with stabilization exercises (Richardson and Jull approach), and twenty-one subjects who received no active treatment. They reported that the differences between pre- test and post-test on Oswestry disability questionnaire and Ronald &Morris questionnaire was ($p<0.05$) when the subject were similar at the baseline ($p>0.05$). The control group, which received no intervention during the trial did not show any change in the outcome measures, unless getting worse. Norris and Mathews (2008), in their high methodological quality study (Score 8/10), enrolled fifty-nine subjects to the trial and divided them to two groups, stabilization group who received integrated back stability exercises (discussed above) for six weeks, while the other group received only passive intervention (back care and advice leaflets). They recorded a considerable reduction in both pain and disability immediately after intervention. In the stabilization group there was up to 89% subject satisfaction, whereas no difference noticed in the control group after the treatment period in either the short-form McGill pain questionnaire or the Ronald & Morris questionnaire.

Bakhitary et al. (2005), in a robust study which failed only in long term follow up, reported similar outcomes when they investigated this treatment on subjects with

chronic lumbar herniated disc. They compared the two groups after four weeks of intervention; then, the opposite was done for the other four weeks. After the first four weeks, there was a meaningful change in the visual analogue scale between the groups ($p<0.0001$), while after eight weeks both groups were equally improved in term of pain ($p=0.23$) and activities of daily living. This result supports the previous finding of importance of stabilization exercises with chronic low back pain in short term follow up.

Table 1. Items of Pedro scale

Item	Description
1	Were eligibility criteria specified?
2	Were participants randomly allocated to groups?
3	Was allocation concealed?
4	Were the groups similar at baseline regarding the most important prognostic indicators?
5	Were all participants blinded?
6	Was there blinding of all therapists who administered the therapy?
7	Was there blinding of all assessors who measured at least one key outcome?
8	Were measures of at least one key outcome obtained from more than 85% of the participants initially allocated to groups?
9	Did all participants for whom outcome measures were available receive the treatment or control condition as allocated or, where this was not the case, were data for at least one key outcome analysed by “intention to treat”?
10	Were the results of between-group statistical comparisons reported for at least one key outcome?
11	Did the study provide both point measures and measures of variability for at

	least one key outcome?

Two papers considered which is more effective: GP intervention; or stabilization exercises. The general practitioner's prescription included regular weekly swimming, walking, and general exercises, as well as pain relievers, such as heat and ultrasound therapy. O'Sullivan et al (1997) treated both groups for ten weeks, and the result showed a high reduction in pain and disability scores for the stabilization exercise group. At twenty months' follow-up the pain intensity decreased to 75.5, $p<0.0001$, pain descriptor reduction =35.8, $p<0.0001$, and 49.1, $p<0.0001$ is the reduction in the Oswestry disability questionnaire. On the other hand, no change recorded for the control group over the treatment period. Moseley (2002) recruited fifty-six participants to the study, and asked the GP group to not look for physiotherapy care. Other exercises and education added to the stabilization exercises in the intervention group. Immediately after the treatment course, Mosley found the reduction in the numerical pain scale was 2.9/10 for the intervention group and 1.4/10 for the GP group. The reduction for the disability scale was 8.3/18 for the intervention group and 4.3/18 for the control group on the Ronald &Morris scale. Although both studies lacked blinding of subjects or therapist, and did not provide intention to treatment, they showed preference for stabilization exercises over GP intervention.

Table 2 Grades of recommendation [36]

Strong evidence	Supported by two consistent level 1
Moderate evidence	Reinforced by two consistent level 2 or 3 studies or two extrapolations from level one study.
Limited evidence	Supported by tow level 4 studies or two extrapolations from level 2 or 3 studies.
Conflicting evidence	Supported by level 5 evidence or troublingly inconsistent or inconclusive studies of any level.

No evidence	Supported by only one or no studies were found.

3.3.4 Comparing spinal stabilization exercises with manual therapy

Two studies compared stabilization exercises with manual therapy and another physiotherapy intervention. Goldby et al. (2006) enrolled (n=213) participants with more than three months of low back pain symptoms, and excluded those who were diagnosed as having lumbar fracture, severe stenosis or a high grade of spondylolisthesis. They divided the participants into three groups (stabilization exercises, manual therapy and education). The stabilization group received specific transversus abdominis and multifidus training in addition to exercises for the pelvic floor and diaphragmatic muscles. However, none of these exercises were prescribed to the other groups. Goldby et al. (2006) concluded that the significant pain reduction was in the stabilization exercises at six months follow-up, while there was no statistical considerable change for the other groups. With regard to disability, the percentage of disability reduction between the first day and twelve months' follow-up for the stabilization group was 38.8% but only 24.5% for the manual therapy group in the Oswestry disability scale. This study considered as a low quality study because it was unable to perform baseline comparability between groups that might lead to statistical bias in the result; and no adequate follow-up performed. Moreover, it failed to blind even the assessors in the trial.

In contras, Ferreira et al. (2007), (n=240) (Pedro score 8/10) compared between motor control exercises (Richardson and Jull approach), manual therapy (manipulation, mobilization), and general gym exercises. Each group prescribed two sessions weekly for eight weeks' treatment. The follow-up the groups for six months and twelve months, visual analogue scale and Ronald &Morris scale were used as secondary

outcome measures. Ferreira et al. (2007) conceded that motor control exercises and manual therapy groups showed better results than the

gym general exercise group at short term follow-ups (eight weeks). The significant pain reduction in the groups was as follows: motor control group (2.5/10), manual therapy group (2.6/10), gym exercise group (2.4/10). The gym exercises group reduced disability the most (7.9/24) at eight weeks. However, there was no clinical or statistical considerable difference at six or twelve months' follow-up. This study showed no preference for stabilization exercises over manual therapy.

Study	Score	Eligibility criteria	Random allocation	Concealed allocation	Baseline comparability	Blind Subject	Blind Therapist	Blind assessor	Adequate F.U	Intension to treat	Between groups	Point estimates and

Table 3. The table showing different criteria from several other authors

You&Lee,2012	5	yes	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes
Koltolis et al 2008	5	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes
Lewis Et al ,2005	5	Yes	Yes	No	No	No	No	Yes	No	Yes	Yes	Yes
Franca et al,2012	8	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Shaughnesy .2004	5	Yes	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes
Childs et al,2004	8	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Miler et al,2004	5	yes	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes
Celestini et al,2005	3	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes
Goldby et al,2006	4	Yes	Yes	No	No	No	No	Yes	No	No	Yes	Yes
Molesely,2002	6	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
O'Sulivan	7	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes

et al,1997												
Bakhitary et al,2005	7	yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes
Caim et al,2006	7	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Koumantakis,2005	7	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes
Norris,2008	8	yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Ferreira et al,2007	8	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Macedo et al,2012	8	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes

3.3.5 Comparing the stabilization exercises with other physiotherapy modalities

A further study contained of many limitations, such as failing to perform a concealment allocation, blinding, and intention to treatment. This study compared the stabilization exercises with the McKenzie approach (Miller et al., 2005). Thirty patients aged between eighteen and sixty years, were divided into two groups. The stabilization exercises were explained as by Richardson and Jull (1995), with pressure gauge under the lumbar region and the use of tactile cues, to ensure the properly isometric contraction of the transversus abdominis and multifidus, as well as avoiding any substitution contraction from trunk superficial muscles. The Mackenzie approach prescribed as by Razmjou et al. (2000). Treatment prescribed based on the patient

assessment and his response to the repetition of movement test. As the result of the assessment, the patients will be classified into one of four syndromes: (i) postural syndrome; (ii)derangement syndrome; (iii)dysfunction syndrome; (iv) 'other' (Razmjou et al., 2000). Both groups showed lower in the McGill pain questionnaire, especially in the pain descriptor (p=0.12). However, no significant change was noticed on all outcome measures between the groups.

Another study compared the segmental stabilization exercises with specific stretching exercises (Franca et al., 2012). There were six weeks of intervention for each group, and each group had fifteen subjects. The stabilization exercises explained as by Richardson and Jull (1995), while the muscular stretching exercises taught for the following muscles: hamstring; triceps surae; erector spinae; and the all the muscular components located posterior to the column, to restore the normal flexibility and biomechanics of the spine. The result showed a significant reduction in all variables ($p<0.001$) in both groups. Pain reduced in the stabilization group more than in the stretching exercise group (99% and 56%, respectively). About disability, the result was 90% and 52%, respectively. This study provided a high quality evidence according to the Pedro score (8/10).

Comparing stabilization exercises with graded activities has been investigated by Macedo et al., (2012) with a high rank for methodological strategies (Pedro score 8/10). The graded activity is developed by Lindstorm et al. (1992), which aimed to promote physical endurance by giving individualized exercises sessions. It was prescribed as exercises for the most problematic or painful movement that patients found difficult to perform. For the stabilization group, this study used tactile cues and real-time ultrasound images technique to ensure the patient was doing the ordered tasks. No meaningful difference between the groups when the author conducted between groups comparison. However, both groups improved in terms of pain disability significantly, in comparison with the baseline and up to twelve months follow up.

You & Lee, (2012) compared the spinal stability exercises with mat exercises. The mat exercises included cobra, butterfly, abdominal breathing exercises, hamstring

stretching, and folding knee to chest. The treatment program ran over four weeks, three times weekly for participants (n=30) and (Pedro score= 5). The result supports both of them with chronic low back pain patients. The visual analogue scale showed a considerable reduction of pain in both groups ($p>0.05$). However, as in the previous study, no difference between the groups. This study provided evidence for the effectiveness of both interventions. However, the high rate of drop out of participants during the follow up to twelve months limited the generalization of the effectiveness of these interventions in the long term.

Kachanathu et al. (2012) conducted a comparative study to compare core stability exercises with conventional physiotherapy in treating fast bowler patients with chronic low back pain. Conventional physiotherapy treatment consisted of back extensors strengthening exercises or back flexors strengthening exercises based on the patient assessment. Patients (n=30) with more than three months of symptoms were recruited for an eight-week treatment program (n=30). Visual analogue scale and Oswestry disability questionnaire were used at the baseline, and immediately at the end of the intervention. The findings of this study when the differences between pre- and post-treatment were studied were: (i) on visual analogue scale (2.20) for the spinal stabilization group and (1.33) for the conventional group; and (ii) on the disability scale (3.83) and (1.18) respectively. The results of this study support the use of stabilization exercises with fast bowlers with chronic low back pain. However, this study suffers from inadequate power because of insufficiency of sample size; the intervention for the intervention group was not described clearly and no randomization was used in the trial.

A high Pedro score (7) study by Cairns et al. (2006) was conducted in a multicentre comparative design, to compare the stabilization exercises with conventional therapy. Participants who were aged between eighteen and sixty years with more than three months of symptoms were included (n=97), while participants who had undergone surgery, with neurological deficits and severe lumbar pathology were excluded. The characteristics at the baseline between the groups were comparable. The stabilization group was treated with exercises that enhanced the endurance of the deep abdominal muscles and lumbar muscles gradually from sitting position to standing, whereas the

conventional group received general exercises, minimal electrotherapy and lumbar traction. The treatment program ran for twelve weeks. Ronald &Morris questionnaires and McGill pain questionnaires were used as outcome measures. Although both groups had considerable changes in both short and long term of pain and disability, the authors failed to perform adequate follow-up for participants. Thus, generalization of the effectiveness of the stabilization exercises for long term is limited. This study showed no preference for the stabilization exercises over the conventional therapy, because they were almost the same at the end of treatment.

3.3.6 Adding of stabilization exercises with other physiotherapy modalities

The combination of stabilization exercises and spinal manipulation has been investigated by Childs et al. (2004). A stabilization program was included in a rehabilitation program which consisted of stretching and strengthening exercises, especially of the deep abdominal muscles and lumbar muscles. One group received only this program, while the other group received this program in additional to spinal manipulation. One hundred and thirty-one patients were treated over four weeks; the Oswestry disability questionnaire and numerical pain rating scale were completed at the baseline, immediately after intervention and six months later. The p value on the Oswestry scale for the manipulation group vs. the exercise group at the baseline was ($p<0.001$), immediately after treatment course ($p=0.006$) and at six months ($p=0.001$). The results showed statistical and clinical significant changes for both groups, but no differences were observed between the groups after treatment or at six months' follow-up. This result leads to suggestions that the stabilization program had the same effects of manipulation therapy, or that stabilization exercises are sufficient to reduce pain and disability regardless of the other combined therapy.

Koumastakis et al. (2005) investigated the usefulness of adding the spinal stabilization program to general exercises in treating patients with chronic low back pain. Twenty-nine patients received general and spinal stabilization exercises twice a week over eight weeks, while twenty-eight received general exercise only over the same period. Although, the result on the Ronald &Morris questionnaire showed short term improvement in the exercise group rather than the combination group, there was no difference between the groups at three months follow up ($p=0.15$ on McGill pain

questionnaire and p=0.15 on Ronald &Morris questionnaire.

Koftolis et al. (2008) studied the effectiveness of adding rhythmic stabilization exercises to TENS in treating women with chronic low back pain. The authors divided ninety-two women into four groups (TENS, Stabilization, TENS+ stabilization and placebo) and prescribed a treatment course for four weeks. The TENS applied as four rubber electrodes and operated at high frequency with pulse duration of (200 us) directly on the patient's pain site. The authors concluded that, in comparison with the baseline the most improvement was seen in the stabilization group ($p<0.05$); the reduction ranged from (26.3% to 42.1%)in the Oswestry disability index and (23.8% to 42.8) decline in the pain scale. At eight weeks' follow-up, the parameters for the stabilization group and the TENS+ stabilization group were similar and higher than for the TENS group. However, this study failed to perform any randomization and concealment allocation; or blinding of participants. Therefore, this study suffers from inadequate power.

Celestini et al. (2005) conducted a low quality study (Pedro score=3). This low score was a result of failing to blind subjects, therapist and assessors; lack of concealed allocation; lack of intention to treatment; and inadequate follow up. They investigated the efficacy of combining stabilizing exercises with orthotic patients who were prescribed orthotics for ninety days, because of lumbar pain and instability. The stabilizing exercises were aimed at the diaphragm breathing muscles, gluteal muscles, pelvic floor and transversus abdominis and multifidus. The exercise protocol ran over four weeks, three times weekly. The participants were assessed after three, six and twelve months. The study conceded that no significant difference was noticed between the groups in the pain and disability scales at any time of the trial. However, pain episodes declined in the last three months to (27%) six episodes the stabilization+ orthotic group.

3.3.7 Applying of stabilization exercises as one-to-one sessions or as group classes

The efficacy of eight sessions of stabilization exercises when added to manual therapy, as one-to-one basis was compared to ten sessions of aerobic stationed exercises (treadmill and cycling), stabilization exercises and manual therapy, as group classes (Lewis et al., 2005). The patients in both groups received three months of intervention and followed up to twelve months. The only finding the authors stated is that the group classes are more cost effective, but the change on the visual analogue scale among the follow up time was similar in both groups and no significant differences noticed.

3.4 Excluded studies

Nine studies eliminated because they are not suitable for the planned inclusion criteria. Five studies excluded because they explored the efficacy of the stabilization exercises on patients with acute low back pain (Hides et al., 1996; Hides, J. et al., 2001; Hodges, Moseley, Gabrielsson& Gandevia, 2003; Monticone et al., 2004; Brennan et al., 2006). Three studies precluded because they discussed the efficacy of stabilization exercises with pregnant women (Elden et al., 2005; Stuge, Veierod, Laerum&Vollestad, 2004a; Stuge, Veierod, Laerum&Vollestad, 2004b). One study eliminated because the sample was post-surgery (Filiz, Cakmak&Ozacan, 2004).

4. Discussion

The rationale behind the stabilization exercises is that there is a less of control or instability in lumbar spine in patients with chronic low back pain (Hodges et al., 1996, Hides et al., 1997). Thus, the main aim of stabilization exercises is to restore the strength and endurance of the muscles that are responsible for the stability of the spine.

4.1 Summary of the main results

Eight hundred and four studies found through the searching in the following databases: CINHAL, Pedro, Ovid, Midline, Pub med, AMED, Google Scholar and Cochrane library; as well as in the search through the citation of related studies.

Eventually, only twenty studies enrolled in the review that included seventeen randomized controlled trials, one cohort study, one case series study and one comparative study. Although the studies used different outcome measures, this review aimed to measure the efficacy of stabilization exercises only in terms of pain and disability, either as primary or secondary measures. The number of participants in the all included studies was 1,557. Disregarding studies that did not specify the gender of participants, the percentage of female participants was higher (62.5%) than male participants (37.5%). About the quality of papers, the vast majority of papers considered as high to moderate quality evidence, while the remaining considered as very low quality.

According to the studies on the effectiveness of lumbar stabilization exercises on patients with chronic low back pain in terms of pain, there is high evidence that stabilization exercises reduce the pain with meaningful results in the short term follow-up (three months). The stabilization exercises showed the capability of reducing pain when compared with no intervention, GPs intervention, compared with other physiotherapy modalities or combined with other physiotherapy modalities. These results of pain reduction based on different measures: the visual analogue scale, numerical pain rating scale, McGill pain questionnaire and the Backill pain scale. Additionally, there is moderate evidence that stabilization exercises can maintain this improvement for long term of follow up (six months, twelve months, and two years) because of the high drop-out rate of participants in the studies.

In terms of disability, all the studies in this review showed the efficacy of stabilization exercises in reducing functional disability in the Oswestry disability questionnaire, and the Ronald &Morris disability questionnaire. Only one study reported that patients had improved in terms of disability, however this improvement was not significant statistically (Koumastakis., et al. 2005). This result leads to the suggestion that the activities of daily living were limited because of pain, since pain reduce the activities regained.

In spite of the improvement in the pain and disability scales, the stabilization exercises did not show any preference over the other physiotherapy modalities, either in the short or long term.

Stabilization exercises showed no preference when combined with other interventions, for instance with spinal manipulation or when added to general exercises, or combined with prescribed orthotic treatment for lumbar instability. In contrast, stabilization exercises proved usefulness when combined with TENS therapy. No difference was detected between performing stabilization exercises in one-to-one sessions and in group classes.

The assessment of eighteen included studies was carried out using the Pedro scale. Two studies were described as having a high risk of bias (score less than 5/10), while fifteen studies were less risk of bias (score equal to or more than 5/10). The rest of the studies included are: case series (Level 4), cohort study (Level 3) and comparative study (Level 2) (Table 2). The methodological quality of the study should be high otherwise; it might lead to biased results (Beaton, Boers and Wells, 2002). The strength of the randomized controlled trial depends on the methodological quality. Blindness is one of the fundamental elements to assess the methodological quality of the study, so absence of this element leads to lower the study's quality (Clamers et al., 1983). On the other hand, it is impractical to blind the participants or practitioners in the physiotherapy settings (Salaffi., 2004). Only one of the included studies has blinded the subjects to the intervention (Cairns et al., 2006), however, no study has blinded the therapist. Five out of seventeen (29.4%) studies have not blind the assessors (Shaughnessy & Caulfield, 2004; Miller et al., 2005; Celestini et al., 2005; Koftolis et al., 2008; You&Lee, 2012).

Randomization is another element which is considered as a necessary point in the designing of studies, especially with randomized controlled trials (Armitage, 1982). In this review, only one study did not prepare for randomization in the trial (Koftolis et al., 2008), whereas 94% of the studies did provide it. With regard to concealment allocation, eight studies performed the concealment appropriately (O'Sullivan et al., 1997; Bakhitary et al., 2005; Ferreira et al., 2007; Norris & Mathews, 2008; Macedo

et al., 2012; France et al., 2012; Childs et al., 2004; Koumantakis et al., 2005), whilst the others failed to perform it.

4.2 Comparison with other reviews

There are many systematic reviews conducted to investigate the efficacy of stabilization exercises on chronic low back pain. However, there are discrepancies in the results of these reviews. Overall, the majority of these reviews lower the efficacy of this technique with chronic low back pain. Johnson and May (2008) conducted a systematic review, which included eighteen randomized controlled trials to determine the role of the stabilization exercises on acute and chronic low back pain. The authors in this review showed the different studies' opinions with a little preference for using stabilization exercises. However, they did not state whether it is effective or not. This review did not support the use of stabilization exercises over other physiotherapy modalities.

The current systematic review agrees with other reviews conducted to check the effectiveness of stabilization exercises on patients with acute and chronic low back pain. Seven randomized controlled trials were included and pain, disability used as part of the outcome measures (Rackwitz et al., 2008). The reviewers stated that stabilization exercises have a similar effect to GP intervention in the acute cases. However, it showed a much better effect than GPs intervention in chronic cases. Furthermore, no differences noticed in the all measures between stabilization exercises and other physiotherapy modalities.

4.3 Limitations of this review

Reviewer worked alone in the data collection process, data analysis and assessing of methodological quality of papers. This might lead to bias in the research's outcomes (Jadad et al., 1998). Selection of the included studies, analysis and assessment depended on the researcher's capability, knowledge and skills. The researcher has tried to be as objective and accurate as possible, to avoid bias in the studies selection. The selection of the included studies warred by inclusion and exclusion criteria, and testing of the provided data selected based on the review question. Critical appraisal of the studies mainly based on the Pedro scale. Additionally, the use of only one data

extractor tool, and the absence of second reviewer may limit the validity of this review..

Another limitation in this review is that some of the studies used small sample sizes (n ≤ 30) in their trials (Miller et al., 2005; Franca et al., 2007; Kanchanathu et al., 2012; Ota et al., 2011; You&Lee, 2012). Small sample sizes might lead to biased outcomes. This comes because of the direct effect of individual performance on the data analysis. Therefore, the generalization of the study's results is limited, and leads to the suggestion that this intervention is only suitable for a particular population. However, the larger samples described as representative of population. A further possible limitation relates to the wide range of participants' ages (from eighteen to sixty years of age). This may result in statistical inconsistency in the outcomes and clinically afterwards.

Inclusion of under power studies, such as case series and cohort studies could be an additional limitation of this review. These types of studies may lead to bias in analysis of the outcomes (Higgins et al., 2008). In addition, there is a variety and heterogeneity of treatment with stabilization exercises among the studies. Some authors used previously used stabilization exercise techniques; others recruited group of muscles that they think are of importance in the stability process. This variety in the techniques and targeted muscles may limit the validation of the result.

4.4 Strength of the review

There are many points that support the strength of this review. Firstly, the search was thorough in the well-known physical therapy electronic databases. Secondly, reliance on the Pedro scale, which defined as having high validity and reliability, for the assessment of quality of the studies (Bhogal et al., 2005). Thirdly, the search strategies, including inclusion criteria, exclusion criteria, population, and outcome measures, were assigned prior to starting to write the review (Higgins et al., 2008).

The review has specified questions and targets a particular population and particular intervention. This point adds additional force to the review (Rys et al., 2009). Moreover, PRISMA guidelines guided this work (Liberati et al., 2009). Finally, the findings of this review obtained in an evidence-based manner.

4.5 Recommendations for future search

Though this review showed moderate evidence on the long-term efficacy of the stabilization exercises on pain scales, a high quality study with a good following-up of participants is required to investigate this issue. Many included papers in this review performed immediate or short-term follow up, while investigating the long-term effect of the stabilization exercises is required. Furthermore, this review did not discuss the effectiveness of stabilization exercises on post-operative patients; a further study could discuss this issue. Using a specific age group is another recommendation of this review, because a wide range of ages might lead to data heterogenetic analysis (Gartlehner et al., 2012). Yet another recommendation for the clinical trials is to measure 'instability' before starting the intervention, and use a standard stabilization exercises protocol rather than the heterogeneity in applying this technique.

Finally, conducting a study with meta-analysis would add strength to the findings of the study, as well as enhancing the statistical power of the study (Cohn & Becker, 2003).

4.6 Conclusion

Lumbar stabilization exercises are useful for treating patients with chronic low back pain at short-term follow up. However, the efficacy of this technique in reducing pain in the long term needs to confirm by studies that are more efficient.

In term of disability, the lumbar stabilization exercises showed the ability to improve disability in patients with chronic low back pain.

However, there is no preference of using the stabilization exercises over the other physiotherapy modalities in treating chronic low back pain. Further research needed to investigate the efficacy of stabilization exercises on pain scales at long term follow-up.

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APPENDICES

Appendix 1: Red flag conditions indicating possible underlying spinal pathology or nerve root problems [4].

Red flags:

• Onset age < 20 or > 55 years
• Non-mechanical pain (unrelated to time or activity)
• Thoracic pain
• Previous history of carcinoma, steroids, HIV
• Feeling unwell
• Weight loss
• Widespread neurological symptoms
• Structural spinal deformity

Indicators for nerve root problems:

• Unilateral leg pain > low back pain
• Radiates to foot or toes
• Numbness and paresthesia in same distribution
• Straight leg raising test induces more leg pain
• Localized neurology (limited to one nerve root)

Appendix 2. Risk factors for occurrence and chronicity of low back pain [4].

Risk factors	Occurrence	Chronicity
Individual	**Age: physical fitness**	**Obesity : low educational**

	:weakness of back and abdominal muscles :smoking	**level :high levels of pain and disability**
Psychosocial	**Stress :anxiety: negative mood or emotions :poor cognitive functioning :pain behavior**	**Distress :depressive mood: somatization**
Occupational	**Manual material handling :bending and twisting : whole body vibration :job dissatisfaction : monotonous tasks : poor work relationships and**	**Job dissatisfaction : unavailability of light duty on return to work : job requirement of lifting for three quarters of the day**

Appendix 3: Components of Passive, Active, and Neural Control Systems (O"Sullivan, 2000).

The passive system constitutes the vertebrae; inter vertebral discs; zygapophyseal Joints and ligaments.

The active system constitutes the muscles and tendons surrounding and acting on the Spinal column.

The neural system, comprising of the nerves and central nervous system, which direct and control the active system in providing dynamic stability.

Appendix 4: Muscle Functional Classification [13].

Local stabilizers: The functional stability role is to maintain low force continuous activity in all positions of joint range and in all directions of joint motion. This activity increases local muscle stiffness at a segmental level to control excessive physiological and translational motion, especially in the neutral joint position where passive support from the ligaments and capsule is minimal. Their activity often increases in an anticipatory action prior to load or movement, thus providing joint protection and support.

Global stabilizers: The functional stability role is to generate torque and provide eccentric control of inner and outer range of joint motion. They need to be able to (i) concentrically Shorten into the full physiological inner range position, (ii) isometric ally hold position and (iii) eccentrically control or decelerate functional load against gravity. They should contribute significantly to rotation control in all functional movements.

Global mobilisers: Muscles, which primarily have a mobilizing role, are required to have adequate length to allow full physiological and accessory (translational) range of joint movement without causing compensatory overstrain elsewhere in the movement system. Their functional stability role is to augment stability under high load or strain, leverage disadvantage, lifting, pushing, pulling or ballistic shock absorption. These muscles are particularly efficient in the sagittal plane, but even though they can generate high forces they do not contribute significantly to rotation control and they cannot provide segmental control of physiological and translational motion.