Core training protocol for a-specific chronic low back pain
Protocol for core training for a-specific chronic low back pain.

Introduction

This protocol was made on request by the physiotherapy and orthopaedic manual therapy practice Orthomedix as part of a bachelor thesis for 2 students at the European School of Physiotherapy, Hogeschool van Amsterdam. It is thus in some ways tailored to this practice, but has been made to also be easily used in other facilities without the need of expensive equipment.

The information presented here is founded on our review of core stability training for chronic low back pain, with supplementary information from reviews on core stability training principles.

The review found, and agrees, with the rest of the literature that exercise is beneficial for chronic low back pain. However, neither the authors of this protocol or previous reviews and guidelines on this topic have been able to conclude with one specific exercise type being superior to all others. This appears to be partly due to an inability or unwillingness to further sub-categorize a-specific chronic low back pain (as this latter part can be very costly), and as such it becomes very difficult to provide a specific intervention to this patient group. Recent guidelines take the view of leaving it up to the therapist and patient preferences as to which type of intervention should be used.

In this protocol we have attempted to make 2 slightly different sets of core stability exercises. One set is a general core stability programme that is more intensive and also shorter, which makes it more time and cost-efficient. The other programme includes extra focus on specific spinal stabilization exercises. These exercises are likely to be more effective when a clinical/functional spinal instability can be found. They are less intense, at least in the beginning, than the general core stability programme, but take more time to perform. Although targeted at patients with clinical instability, they show similar benefits to the general programme in patients without instability and can thus be prescribed to patient if it is desired; such as if the more intense exercises of the general programme are too provocative. This also means that an exercise programme can be tailored for a specific patient with exercises taken from both programmes if deemed appropriate.

Core stability training principles.

Core stability training is a term that has been referred to under many different names: Lumbar stabilization; Dynamic stabilization; Motor control (neuromuscular) training; Neutral spine control; Muscular fusion; Trunk stabilization. In essence, it is the training aimed at improving the muscular control around the lumbar spine to maintain functional stability. Its use has been spread to a variety of disorders and aims, such as low back pain, musculoskeletal injuries and to increase the performance of athletes. This review will stick to the general ideas of core training and emphasise only the parts to do with low back pain specifically.
The core has been described by Richardson et al (1999) to be a box with the abdominals in the front, paraspinals and gluteals in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom (figure 1). These muscles make up the active part of the 3-part system controlling the spine, which we will get back to later. They are of importance as without these muscles, we would be unable to keep the spine stable not only in movements, but also in postures requiring much less than opposing the weight of the upper body (Crisco et al, 1992). Without muscles the load on other structures in the spine, such as the intervertebral disc and facet joints would be greater.

It is common to view these muscles as a muscular corset around the lumbar spine that works as unit to stabilize the spine and the body (Akuthota & Nadler, 2004). They work together via a system of co-contractions. Co-contractions (simultaneous contractions) can be either synergists helping agonists in performing movements, but also includes co-contracting antagonists to apply an opposing force in order to ensure stability.

The core is the centre of the functional kinetic chain that is the human body and core needs to be stable in order for humans to have sustainable healthy postures and to successfully move limbs and perform functional tasks. Konin et al (2003) describes the “serape effect”, where co-contractions of the core, via the thoracolumbar fascia, provides ample proprioceptive stimulus. This stimulus enables adjacent body parts to respond accordingly for optimal performance. An example of this is for instance overhead activities in athletes where the torque and counter torque of diagonally related muscles retains optimal stability throughout the movement. The core also needs to be stable to ensure optimal energy transfer from upper to lower limbs and vice versa. If the core is not stable and thus allows excessive movement and loss of control around the vertebrae, some energy will be lost with every little movement that is allowed in the kinetic chain (this also holds true for all joints in general). When the system works as it should, the result is proper force distribution and maximum force generation with minimal compressive, translational, or shearing forces at the joints of the kinetic chain (Fredricson & Moore, 2005).

Panjabi (1992) describes the effects of a dysfunctional spinal system in the following manner: “(1) Injury, degeneration and/or disease may decrease the (2) passive stability and/or (3) active stability. (4) The neural control
unit attempts to remedy the stability loss by increasing the stabilizing function of the remaining spinal components: (5) passive and (6) active. This may lead to (7) accelerated degeneration, abnormal muscle loading, and muscle fatigue. If these changes cannot adequately compensate for the stability loss, a (8) chronic dysfunction or pain develop.”

ANATOMY

The stability of the lumbar spine does not only rely on the muscles. It is a 3-part system that Panjabi (1992a) divided into:

- Neuromuscular control (neural elements)
  - Central nervous system and peripheral nervous system (coordination, proprioception, reflexes etc.)

- Passive subsystem (osseous and ligamentous elements)
  - Ligaments, facets, lamina, pars interarticularis, pedicles, intervertebral discs and vertebral body

- Active subsystem (muscular elements)
  - Muscle bellies and tendons

Spinal stability will be compromised if structures in one of these groups are disturbed. Instability can vary in amount and cause. Gross instability is a marked displacement of vertebrae that can be seen on radiographic imaging. This often also involves neurological deficit and deformity (Akuthota & Nadler, 2004). Functional instability on the other hand is defined by as a relative increase in the neutral zone. This neutral zone was described by Panjabi (1992b) as “the part of the range of physiological intervertebral motion, measured from the neutral position, within which the spinal motion is produced with a minimal internal resistance”. The neutral position is the positioning of the spine in which overall internal stresses in the spinal column and the muscular effort to hold the posture are minimal. We can achieve active stability by muscular co-contraction

Muscular anatomy

The coordination of all the muscles surrounding the lumbar spine are critically important for stability and movement in the lumbar spine. Recent research (Hides 1996, Hodges 1996, Richardson 1999) has advocated the importance of a few muscles (in particular, the
transversus abdominis and multifidi), and reported that the multifidi have been found to atrophy in people with chronic LBP (Hides, 1996). However, it appears that both deep and superficial core muscles are needed for optimal stabilization and performance (Akuthota, & Nadler, 2004). To acquire this co-contraction, precise neural input and output are needed.

Another structure of great importance is the thoracolumbar fascia. The thoracolumbar fascia has in recent reviews been regarded as “nature’s back belt” (Akuthota & Nadler, 2004). The thoracolumbar fascia offers large attachments on its middle and posterior layers to the transversus abdominis (Bogduk, 1997). The deep lamina of the posterior layer attaches to the processus spinosi at the lumbar level. McGill (2002) sees the thoracolumbar fascia as serving as part of a “hoop” around the trunk and according to Vleeming et al (1995) it provides a connection between the lower and upper limbs. The thoracolumbar fascia also has a neural factor in that it provides proprioceptive input of the position of the trunk when its muscular components contract.

There are two main types of muscle fibers; slow-twitch and fast-twitch. This, of course, also holds true for the core muscles. Their different types determine their functions. The Queensland research group (Richardson et al, 1999) has suggested the differentiation of local and global muscle groups to outline the postural segmental control function and general multisegmental stabilization function for these muscles groups, respectively (table 1)

<table>
<thead>
<tr>
<th>Local/Deep Muscles (postural, tonic, segmental stabilizers, aerobic)</th>
<th>Global/Superficial Muscles (dynamic, phasic, torque producing, anaerobic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multifidi</td>
<td>Rectus abdominis</td>
</tr>
<tr>
<td>Psoas major</td>
<td>External oblique</td>
</tr>
<tr>
<td>Transversus abdominis</td>
<td>Internal oblique (anterior fibers)</td>
</tr>
<tr>
<td>Quadratus lumborum</td>
<td>Iliocostalis (thoracic portion)</td>
</tr>
<tr>
<td>Diaphragm</td>
<td></td>
</tr>
<tr>
<td>Internal oblique (posterior fibers)</td>
<td></td>
</tr>
<tr>
<td>Iliocostalis and longissimus (lumbar portions)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Key muscles of the core

The local muscle system (the deep muscle layer) are primarily made up by slow-twitch fibers, although they do contain important fast-twitch fibres. One example of this is the multifidus where the deep fibres are slow-twitch and the superficial fibres are fast-twitch (McDonald 2006). These primarily aerobic muscles are short in length and are suited for controlling intersegmental motion and responding to changes in posture and extrinsic loads (Akuthota et al, 2008). The most important of these muscles can be seen in table 1.

The fast-twitch fibers belong to the global muscle system (the superficial muscle layer, table 1). These muscles can also be referred to as prime movers, as they are long and possess large lever arms that permit the production of large amounts of torque and gross movements.

One of the most important parts of the core is the abdominals. Recent reviews and articles have directed their attention to the transversus abdominis for its stabilizing effects. The fibres
of the transversus abdominis run horizontally (except for the most inferior fibers, which run parallel to the internal oblique muscle), creating a belt around the abdomen.

Abdominal “Hollowing in” of the abdomen promotes contraction of the transversus abdominis and internal oblique with minimal contraction of rectus abdominis (O'Sullivan, 1997, Strohl et al, 1981). The transversus abdominis and multifidi have been shown to contract 30 ms before movement of the shoulder and 110 ms before movement of the leg in healthy people, and the theory is that they do this to stabilize the lumbar spine (Hodges & Richardson, 1996, Hodges & Richardson, 1999). Patients with LBP on the other hand have delayed contraction of the transversus abdominis and multifidi prior to limb movement (Hodges & Richardson, 1996). Another factor contributing to spinal stability is the intra-abdominal pressure (McGill, 2002). Through the thoracolumbar fascia, the internal oblique and the transversus abdominis may increase this pressure by working together to tighten the “hoop” the thoracolumbar fascia creates. Cholewicki et al (1999) claim that the abdominals (and multifidi) only need 5-10% of their maximal volitional contraction to stiffen spinal segments. This would indicate these muscles’ suitability to perform this action for a longer period of time and could also be an indicator that core exercises need not be felt as especially taxing on the patient as opposed for instance regular strength training.

The hip musculature is of the utmost importance in all ambulatory activities, and also enjoys a key role in stabilizing the trunk and pelvis in gait (Lyons et al 1983). Delayed firing and poor endurance of the hip extensor (gluteus maximus) and abductor (gluteus medius) muscles have previously been noted in people with LBP (Beckman & Buchanan 1995).

The psoas muscle is mainly a hip flexor, but also functions as a weak flexor of the lumbar spine (Bogduk, 1997). Although the function in the lumbar spine is small, it has potential to exert extensive compressive forces on the intervertebral discs in the lumbar spine. Full sit-ups and other activities that promote maximal psoas contraction can exert a compressive load on the L5-S1 disc equal to 100 kg of weight (Bokduk, 1997). Tightness of the psoas muscle may be an added cause of LBP by increasing compressive loads to the lumbar disks.

As mentioned before the pelvic floor can be seen as the floor of the core “box” with the diaphragm working as the roof. Diaphragm contraction increases intra-abdominal pressure and thus adds to spinal stability. The pelvic floor musculature has been shown to coactivate with transversus abdominis contraction (Sapsford, 2000).

The osseoligmentous structures of the lumbar spine impart passive stiffness. Injuries to the tissues of any of these structures may cause functional instability. At the posterior of the
spine, we find facet joints, lamina and pars interarticularis. These structures are slightly flexible, but repetitive loading of the inferior articular facets with excessive lumbar flexion and extension may lead to failure. The facet joints only ever carry significant load in a few positions, such as excessive lumbar lordosis (Bogduk, 1997).

The intervertebral disc is made up by the annulus fibrosis, which contains the nucleus pulposus, and at the top and bottom are the endplates. Compressive and shearing loads can damage the discs. Initially the damage is done to the endplates, but through further loading the annulus will also sustain damage, with the risk of posterior disc herniation. A lack of muscular control may, through the theory of the 3-part system, increase the load on the disc. This may turn into a viscous cycle where the muscles aren’t able to protect the disc and the discs ability to provide stability is diminished and thus requires even more by way of compensation from the muscles. The ligaments of the spine do not provide much stability in the neutral position of the spine. Solomonow et al (1998) suggest that they might rather play a larger role in supplying the neural system with proprioceptive information about the lumbar spine.

**How it is set up and supposed to be used**

This protocol has been designed with three parts. The programme starts with a warm up which both sets of patients should do. Then the programme splits up into two sections: the specific stability exercise section and the general core exercise section. As mentioned before in the introduction these two sections have been tailored for specific patients in mind, with the specific stability exercises aiming to train patients that show signs of clinical instability and the other group of exercises for patients without signs of clinical instability.

Both programmes are made up of eight stages that the patient should work through. These stages increase in difficulty and load on the spine. In each stage there are a set of exercises described that show how to perform exercises in this stage of the training. The exercises that are described below are useful exercises to start with when entering each stage but can be adapted, changed, and other similar exercises can be imagined up and placed in.

Here are some examples of how to make the exercises harder:

- Have the patient decrease their base of support i.e. when sitting place feet closer together, or when lying supine go from supporting with the both arms down to just both elbows and then to shoulder etc.

- Have the patient support themselves with 1 less arm/leg. i.e. when sitting raise one leg off the ground, or when bridging supine raise own leg off the floor, or lift one hand off the floor when performing an exercise that requires the patient to rest on hands (press-up position).

- Increase the duration of the hold of a specific posture/position.
• Distract the patient with an extra task such as, holding a conversation during their exercise, catching and throwing a ball, moving arms/legs in a specific controlled pattern, etc.

• Add external load to push patient off balance, slight extra weight (pulley machine, dumbbells), pushing and pulling on patient during exercises, etc.

(note that if the exercise is too hard, the opposite of the above mentioned points can be done to make the exercise slightly easier.)

With the exercises that involve the patient holding a static posture, the patient is to sustain the posture for 10 seconds and repeats this 10 times each series. A short rest of 3-4 seconds I sufficient between each repetition. If this is too hard the patient can start with holding the posture for shorter durations and with fewer repetitions.

Once the patient is able to carry out all the exercises in any particular stage comfortably and, when applicable, to the required duration of 10second hold repeated 10 times, then the patient can progress to the next stage in the programme.

Factors that could be used to assess which patients would be likely to respond favourably to core stability training: (Akuthota et al, 2008)

• Age, the younger the patient the more likely they are to respond to training

• General flexibility, the better the general flexibility of the patient the better they will perform

• Positive prone instability test, gives good indication that stability training will have an effect on patients complaints

• Presence of pain during spinal range of motion testing (painful arc, abnormal lumbopelvic rhythm, use of support with arms or thighs).

Because of the lack of sub-grouping available in the literature, we are only able to present two different exercise regimes; one specifically aimed at instability and the other aimed at a-specific chronic LBP in general. Recent literature does however state that exercise programmes should be tailored to the specific patient. This includes amongst others the patient’s prior functioning, ADLs, goals and other limiting or contributing factors. For this specific group of complaints, however, some part must be left up to the treating physiotherapist’s clinical reasoning and clinical picture of the patient. Although perhaps too unreliable to be used in research, physiotherapists have many tests available to them to provoke structures connected to a-specific chronic LBP such as facet joints and intervertebral discs. In doing these tests, one may attempt to narrow down to more or less irritated/damaged structures. For instance, KEMP-testing may be used to identify facet arthritis and if this is seen one should then avoid exercises which provoke this, such as extreme lumbar extension. Another example is the intervertebral disc, which may be provoked by for instance a slump-test. If a discopathy is suspected, certain exercises that include a lot of hip flexion force, such
as crunches, should be avoided as the psoas muscle has the ability to exert massive forces on the lumbar discs.

Some interesting tests have been notified to help show and record the progress of patients:

- Oswestry Low Back Pain Disability Questionnaire and Roland Morris Disability Questionnaire can be used to assess changes in disability with patients.

- VAS scale can be used to determine the level of pain a patient is experiencing.
**Warm Up**

The warm up is the same for both exercise programmes and consists of light aerobic work followed by stretches.

**Light aerobic work:** 5 min biking

*Biking has been chosen for the aerobic section of the warm up as it offers the least pressure and load onto the spine out of all the aerobic equipment in the clinic. Be sure to have the patient seated correctly with an active posture as close to the lumbar neutral position as possible.*

**Stretching**

Stretches are to be performed after an aerobic warm up. Note that some stretching exercises could be too provocative for a patient and may need to be skipped depending the patient’s level of training and pain level.

Each stretch should be held for 15-20 seconds and pain should not be provoked.

**Back stretches:**

- Single and double knee to chest from supine position,

  *Supine lying patient uses hands to help lift one/two leg(s) to their chest, bringing the spine into flexion.*

- Alternate spinal flexion-extension from 4-point kneeling position,

  *Also known as the “cat and camel” the patient slowly arches the spine into maximum flexion and then moves it into maximum extension while in 4point kneeling position.*

- Trunk forward stretching in praying position,

  *Patient sits on their knees with buttocks touching the heels and patient places hands on the floor in front of the. Patient slowly slides hands across the floor reaching out as far as possible.*
• Side bending in standing position with and without contralateral arm elevation. 
  *Patient performs lateral flexion either with arms by their side or both elevated to 90 degrees of abduction at the shoulder.*

• Low back sustained rotation from supine position, 
  *Patient lies supine, bends one knee to 90 degrees of flexion and rotates pelvis to the other side so that the flexed leg is on top and the knee is on other side of body. Patient then rotates shoulders in opposite direction to the rotation of the pelvis.*

**Pelvic/leg stretches:**

• Illiopsoas stretch, 
  *Patient kneels down (marriage proposal position) resting with one leg on its knee and the other on the foot. The patient places the knee resting leg (leg to be stretched) into hip extension by moving weight more to the front leg in order to stretch the hip flexors. More stretch can be applied by placing the leg into internal rotation.*

• Hamstring muscle stretch, 
  *Patient kneels on one leg (marriage proposal position) and extends the other leg out in front of them. With that leg at full extension at the knee the patient brings the hip into flexion until a stretch is felt.*

• Adductor muscle stretch 
  *Patient performs simultaneous hip abduction in sitting position and reaching forward with back straight*
Specific stabilizing exercises

*For all exercises with an isometric contraction: hold the contraction/posture for 10 seconds and repeat 10 times with a short rest (3-4 seconds) between each contraction. If unable to sustain contraction/posture for 10 seconds, perform to best ability and complete 10 repetitions.

*Patient is able to progress with the exercises when they are able to perform the exercise comfortably and able to perform 10 repetitions of 10 seconds duration successfully.

*Patient should perform homework exercises for 30 min at least 3 times a week

Facilitation:
Perception development of specific isometric contractions of the stabilizing muscles.

Stage 1:

Hollow Abdomen: lying prone/4point kneeling

Contraction (isometric) of transverse abdominis to tuck in the lower abdomen and make hollow.

Figure 2: Hollow abdomen

Multifidus contraction (isometric) perception

Therapist palpation of multifidus muscle with patient sitting or standing. Patient slowly anteflexes contralateral arm to the palpated multifidus muscle. Activation of the multifidus should be felt just before or at the beginning of movement immediately lateral to the spineous process.

Figure 3: Palpation of multifidus

Stabilizer- biofeedback

Patient lying supine with stabilizer sack placed underneath lumbar region of the spine. The patient then holds specific positions, which include: slight crunched position, lifting one/two leg(s), raising and crossing over of one arm, etc. An indication that the correct, stabilizing muscles are active is that the pressure displayed in the gauge should vary in the different positions.

Figure 4: Use of biofeedback
Stage 2:

Co-contraction (isometric) of stabilizing muscles

Patient in sitting and standing positions repetitively co-contracts the multifidus and transverse abdominals, gradually increasing the contraction time.

Lumbar stability with light dynamic tasks:
Control of lumbar neutral zone posture with light movements without external resistance.

Stage 3:

Isolated movement of surrounding body areas while sustaining lumbopelvic posture

Sitting on chair (stable surface) with feet on the ground. The patient slowly moves body parts (e.g. arms, legs, thoracic spine) while keeping the lumbopelvic posture in the, correct, neutral zone.

Movements include:

- Leg abduction (bilaterally)
- Hip flexion bringing heels off the ground(slight)
- Arm horizontal abduction (elbows extended)
- Arm rotation
Stage 4:

Control of posture in neutral zone as well as other postures away from the neutral zone

Co-contraction of the stabilizing muscles (isometric) in varied lying positions, sustaining the lumbar position throughout slow movements.

Movements include:

- **Horizontal hip Abduction** (crook lying position)
- **Heel slides** (crook lying position)
- **Hip abduction** (Side lying)
- **Knee and hip flexion** (Side lying)

When these exercises can be performed comfortably the patient can begin to apply the isometric co-contraction for aggravating postures in ADL tasks, such as: gardening, ironing, vacuum cleaning etc.
Stage 5:

Control of lumbopelvic region during light movements

Sitting on unstable base of support (i.e. Swissball, busoball, cushion) with co-contraction (isometric) of the stabilizing muscles:

Start with light movements of the lumbar spine, thoracic spine, hip, all individually. Balancing in specific positions.

Increase to lifting one leg and holding position, alternating legs with the repetitions.

Increase to 3-plane movements

When these exercises can be performed comfortably the patient can apply the co-contraction of the stabilizing muscles during normal speed walking (and other light activities).
**Lumbar stability with heavy-load dynamic tasks:**

Control of lumbopelvic region during heavy movements

**Stage 6:**

**Bridging exercise**

Lying supine in crook-lying position, patient raises their pelvis until their body is held straight, in one line, with lumbar spine in neutral position and hold position.

*Figure 19: Bridging*

**Leg cycling**

Patient is lying supine with hips and knee flexed to 90 degrees. Performs cycling motions with hips at roughly 90 degree angle.

*Figure 20: Leg cycling*

**Single leg extensions (4 point)**

Patient starts in a 4-point kneeling position. Extends one leg backwards, taking care that the spine stays in neutral position and does not rotate or extend further.

*Figure 21: Single leg extension*

Increasing load and complexity while maintaining lumbar stability

**Stage 7:**

**Single-leg bridging**

Lying supine in crook-lying position with one leg off the floor (knee extended), patient raises their pelvis until their body is held straight, in one line, with lumbar spine in neutral position and hold position.

*Figure 22a7: Start position*  
*Figure 22b: Single-bridge*
**Bridging on unstable surface**

*Lying supine with lower legs resting on unstable surface (Swissball), patient raises their pelvis until their body is held straight, in one line, with lumbar spine in neutral zone and hold position.*

![Figure 23a: Start position](image1)
![Figure 23b: Bridge position](image2)

**Single leg and arm extension (4 point knee)**

*Patient starts in a 4-point kneeling position. Extends one leg backwards and opposite arm forwards, taking care that the spine stays in neutral position and does not rotate or extend further.*

![Figure 24: Single leg and arm extension](image3)

**Single leg and arm extension (prone)**

*Patient starts in prone. Extends one leg backwards and opposite arm forwards, taking care that the spine stays in neutral position.*

![Figure 25: Single leg and arm extension (prone)](image4)

**Arm and leg lifts (contralateral) sitting on unstable surface (swissball)**

*Patient sits on unstable surface (Swissball) with lumbar spine in neutral position. Patient extends one leg off the floor and anteflexes the contralateral arm until they are both straight out in front, perpendicular to the patient.*

![Figure 26: Arm and leg lift (unstable surface)](image5)
When patient can perform these exercises comfortably they can apply co-contraction of stabilizing muscles with faster walking.

Stage 8:

**Single-leg bridging with unstable surface**

*Lying supine with lower legs resting on unstable surface (Swissball. Patient raises one leg off the unstable surface and then raises their pelvis until their body is held straight, in one line, with lumbar spine in neutral zone and hold position.*

![Figure 27a8: Start position](image1)

![Figure 27b9: Bridging position](image2)

**Bridging with rotations**

*Lying supine in crook-lying position, patient raises their pelvis until their body is held straight, in one line, with lumbar spine in neutral zone. Patient then slowly rotates their pelvis from side-to-side.*

Patient can apply functional co-contractions to walking with changing speeds.
General trunk strengthening

The series and repetitions for these exercises are left up to the therapists’ judgement on an individual basis per patient.

Stage 1 and 2:

Curl-up (straight):

Patient lies supine with legs straight. Hands fill space between low back and exercise mat. Lift head and shoulders off the floor.

Figure 1: Curl-up (straight)

Curl-up (knees bent):

Patient lies supine with knees bent. Lift head and shoulders off the floor.

Figure 2: Curl up(knees bent)

Prone back extension:

Patient starts in prone position with a pillow under the stomach and the arms by the side. Lifts trunk to neutral position.

Figure 3: Prone back extension
Stage 3:

Heel slides:

*Patient starts in the crook-lying position. Slowly slides the heel down the table, then brings it back up to start position*

![Figure 4: Heel slide](image)

![Figure 5: Crook-lying](image)

Lower abdominal crunch:

*Patient is lying supine with hips and knees flexed to roughly 90 degrees. Arms are resting at the side. Move knees towards the head without excessive flexing in the hips.*

![Figure 6: Lower abdominal crunch](image)

Bridge:

*Lying supine in crook-lying position, patient raises their pelvis until their body is held straight, in one line, with lumbar spine in neutral zone and hold position.*

![Figure 7: Bridge](image)

Prone back extension:

*Patient starts in prone position with a pillow under the stomach. Lifts trunk to neutral position while arms held elevated.*

![Figure 8: Prone back extension](image)
**Stage 4:**

**Heel slides:**

Patient starts in the crook-lying position. Slowly slides the heel down the table, then brings it back up to start position.

Figure 9: Heel slide

**Lower abdominal crunch:**

Patient is lying supine with hips and knees flexed to roughly 90dg. Arms are resting at the side. Move knees towards the head without excessive flexing in the hips.

Figure 10: Lower abdominal crunch

**Bridge:**

Lying supine in crook-lying position, patient raises their pelvis until their body is held straight, in one line, with lumbar spine in neutral zone and hold position.

Figure 11: Bridge

**Prone back extension:**

Patient starts in prone position with a pillow under the stomach. Lifts trunk to neutral position while arms held elevated.

Figure 12: Prone back extension
Single leg extension (prone):

Patient starts in prone. Extends one leg backwards, taking care that the spine stays in neutral position.

Figure 1: Single leg extension (prone)

Single leg extension (4 point):

Patient starts in a 4-point kneeling position. Extends one leg backwards, taking care that the spine stays in neutral position.

Figure 2: Single leg extension (4-point)

Stage 5:

Leg lifts:

Patient starts in supine with arms resting at the side. Lifts straight leg toward ceiling. Pay attention to lumbar position.

Figure 3: Leg lifts

Leg cycling:

Patient lies supine with knees flexed to 90 degrees. Performs cycling motions with hips at roughly 90 degree angle.

Figure 4: Leg cycling
Lower abdominal crunch:

Patient is lying supine with hips and knees flexed to roughly 90 degrees. Arms are resting at the side. Move knees towards the head without excessive flexing in the hips.

Simple hip lift:

Patient is lying on his side, supported on the elbow and lowest-lying knee. Lifts self-up so that the body is straight.

Back extensors: as in stage 4

Stage 6:

Full abdominal crunch:

Patient is lying supine and performs full abdominal crunches, taking care to flex in the entire spine, with knees bent

Leg lifts:

Patient starts in supine with arms resting at the side. Lifts straight legs toward ceiling and back.
Leg cycling:

Patient lies supine with knees flexed to 90 degrees. Performs cycling motions with hips at roughly 90 degree angle.

Simple hip lift:

Patient is lying on his side, supported on the elbow and lowest-lying knee. Lifts self-up so that the body is straight.

Single leg and arm extension (prone):

Patient starts in prone. Extends one leg backwards and opposite arm forwards, taking care that the spine stays in neutral position.

Single leg and arm extension (4-point):

Patient starts in a 4-point kneeling position. Extends one leg backwards and opposite arm forwards, taking care that the spine stays in neutral position.
Single leg bridge:

*Patient lies supine with 1 leg bent and on the ground and the other stretched out alongside it. Then performs a single-leg bridge.*

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Arm / leg lift on ball:

*Patient sits on the Swissball and alternates lifting right arm/left leg and vice versa.*

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Stage 7:

Arm / leg lift:

*Patient is lying on his back on a mat. The leg and arm on the same side is lifted-lowered. Repeat with the other leg and arm.*

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Full abdominal crunch:

*Patient is lying supine and performs full abdominal crunches, taking care to flex in the entire spine, with knees bent*
**Leg lifts:**

Patient starts in supine with arms resting at the side. Lifts straight leg toward ceiling.

![Figure 17: Leg lift](image)

**Leg cycling:**

Patient lies supine with knees flexed to 90 degrees. Performs cycling motions with hips at roughly 90-degree angle.

![Figure 18: Leg cycling](image)

**Advanced hip lift:**

Patient is lying on his side, supported on the elbow and lowest-lying foot. Lifts self-up so that the body is straight.

![Figure 19: Advanced hip lift](image)

**Single leg and arm extension (prone):**

Patient starts in prone. Extends one leg backwards and opposite arm forwards, taking care that the spine stays in neutral position.

![Figure 20: Single leg and arm extension (prone)](image)
Single leg and arm extension (4 point):

Patient starts in a 4-point kneeling position. Extends one leg backwards and opposite arm forwards, taking care that the spine stays in neutral position.

Abdominal curl:

Patient is in prone position, supported on extended arms with lower legs on the ball. Patient pulls legs toward chest, bringing the ball with him.

Stage 8:

Arm / leg lift:

Patient is lying on his back on a mat. The leg and arm on the same side is lifted-lowered. Repeat with the other leg and arm.

Leg cycling:

Patient lies supine with knees flexed to 90 degrees. Performs cycling motions with hips at roughly 90 degree angle.
Full oblique abdominal crunches:

Supine with knees bent and both hands behind head. Move elbow of one hand behind head towards opposite knee.

Advanced hip lift:

Patient is lying on his side, supported on the elbow and lowest-lying foot. Lifts self-up so that the body is straight.

Single leg and arm extension (prone):

Patient starts in prone. Extends one leg backwards and opposite arm forwards, taking care that the spine stays in neutral position.

Single leg and arm extension (4 point):

Patient starts in a 4-point kneeling position. Extends one leg backwards and opposite arm forwards, taking care that the spine stays in neutral position.
**Oblique abdominal curls on ball:**

Patient is in prone position, supported on extended arms with lower legs on the ball. Patient pulls the right knee in the direction of the opposite shoulder. Repeat with left knee towards right shoulder.

**Figure 29: Oblique abdominal curl on ball**

**Single-leg bridging on ball:**

Patient is in supine position with 1 leg resting on the Swissball and the other elevated above it. Patient then performs a bridge.

**Figure 30: Start position single leg bridging on ball**

**Figure 31: End position single leg bridging on ball**
References:


