

## 5. An Exercise Programme to Enhance Lumbar Stabilisation

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### **Key Words**

Exercise, lumbar stabilisation, motor learning.

### **Summary**

The concept of sensory-motor stimulation is introduced and the importance of sub-cortical control of active lumbar stabilisation (ALS) is emphasised. The ALS programme is divided into four stages representing muscle re-education, static stabilisation, dynamic stabilisation and functional activities.

In stage 1 the oblique abdominals, transversus abdominis, and multifidus are facilitated. Abdominal hollowing (AH) is used to dissociate rectus abdominis activity from that of the other abdominal muscles. AH is performed by pulling the abdomen in without allowing significant lumbar flexion. Pressure biofeedback is used to monitor the depth of the lumbar lordosis and give information concerning maintenance of lumbar stabilisation.

In stage 2, load is imposed on the trunk in various starting positions while the subject braces the trunk muscles. The lumbar spine is held in mid range while exercising, an alignment termed the 'neutral position'.

In stage 3 emphasis is placed on the restoration of correct pelvic tilting. Patients are taught to exercise within their pain-free range of motion, a position termed the functional position or safety zone.

Stage 4 describes functional exercises. The importance of proprioceptive training is discussed, and stabilisation activities using a 65 cm gymnastic ball are described. Stabilisation programme results are briefly reviewed.

### **Introduction**

The stabilising system of the spine may be divided into three sub-systems. Passive stabilisation is provided by the non-contractile tissues, active stabilisation by the contractile tissues, and neural control by the nervous system. Of these three sub-systems it is the active and neural control systems which may be enhanced by exercise therapy both for rehabilitation and as part of a preventive healthcare programme. Improvement of these systems may in many cases compensate for a decrement in the passive system and reduce spinal dysfunction (Panjabi, 1992).

### **Sensory-motor Stimulation**

Restoration of active lumbar stabilisation is part of a more general approach to rehabilitation which follows a sensory-motor format (Janda and Vavrova, 1992). In this approach, following assessment, tight muscles are stretched and inhibited (weak) muscles are stimulated and re-strengthened. The final and essential stage in the rehabilitation process is to convert the conscious (cortical) control of the corrected movements to an unconscious (sub-cortical) level. This is achieved by increasing sensory stimulation, giving an improved activation of the sub-cortical regulatory systems. Because this process does not rely on conscious control, it is faster and the stabilising process becomes 'second nature'.

The faster sub-cortical control system leads to a reduced muscle reaction time. Increases in muscle reaction speed may be learnt, and this process has been shown to improve the stability of peripheral joints, the pelvis, and the lumbar spine (Saal and Saal, 1989; Konradson and Ravn, 1990; Bullock-Saxton *et al*, 1993).

Sub-cortical control of stabilisation can be achieved by proprioceptive exercise on a labile surface such as a balance board or gymnastic ball (Bullock-Saxton *et al*, 1993). Once this has occurred, a subject is able to concentrate on the activities of daily living, rather than focusing on the maintenance of active lumbar stabilisation. If muscle contraction can be made to occur rapidly enough to stabilise the spine when an external force is imposed, end range stress on the spine is reduced, pain is lessened, and function improved.

### **Achieving Active Lumbar Stabilisation**

The active lumbar stabilisation (ALS) programme may be divided into four overlapping stages (Paris, 1993; Jull and Richardson, 1994) (table 1).



**Table 1: Exercise sequence for active lumbar stabilisation** (Paris, 1993; Jull and Richardson, 1994)

- Stage 1: Re-education of stabilising muscles.
- Stage 2: Exercise progressions for static stabilisation.
- Stage 3: Exercise progressions for dynamic stabilisation.
- Stage 4: Occupational / activity specific stabilisation.

In stage 1 the patient is reminded how to use the muscles responsible for stabilising the spine, and how to begin to break long-held movement patterns. Once this is achieved, in stage 2 the target muscles are held contracted as progressively more difficult exercises are performed. Stage 3 teaches controlled movement of the lumbar spine within a functional pain free range. During stage 4 speed is progressed, and functional movements specific to the patients' normal activities are rehearsed.

## Justification for Exercise Selection

Spinal stability can be enhanced by facilitating a co-contraction of the muscles surrounding the lumbar spine (Richardson *et al*, 1990). The oblique abdominals and transversus abdominis are particularly important in this respect because of their involvement in the thoracolumbar fascia (TLF) mechanism and in enhancing intra-abdominal pressure (IAP). These laterally placed abdominal muscles lose their stability role quickly (Nouwen *et al*, 1987). Loss of stabilising support of this type has been proposed as one mechanism responsible for industrial and recreational injury of the spine (Parnianpour *et al*, 1988).

The erector spinae are concerned in the hydraulic amplifier effect, and multifidus is important to the adjustment of individual lumbar segments (Aspden, 1992). The stabilising role of multifidus is quickly lost with the onset of low back pain, with ultrasonic imagery of this muscle showing wasting on the ipsilateral side of a lesion (Hides *et al*, 1994).

The rectus abdominis and lateral fibres of the external oblique are not as important to spinal stability because they are essentially prime movers of trunk flexion rather than lumbar stabilisers (Miller and Medeiros, 1987). The rectus abdominis is distant from the lumbar spine, giving it a larger leverage effect more suitable for its action as a prime mover of the trunk and pelvis (Richardson *et al*, 1992).

During pelvic tilting actions, both the lower fibres of rectus abdominis and the gluteals are worked, but multifidus activity reduces (Richardson *et al*, 1992). A stabilisation programme should therefore involve some work for both the lower rectus and the gluteals (Richardson *et al*, 1990; Bullock-Saxton *et al*, 1993), as correct pelvic tilting is an essential motor skill required for stability development.

The group action of muscles must also be considered. Action as a prime mover is only one aspect of muscle function. Equally important is the ability of a muscle to act as a stabiliser. This characteristic is illustrated well by the IAP mechanism itself. This mechanism not only functions when the spine lifts in a cantilever position; some of the highest recorded IAP values occur during overhead pressing movements. In this action the spine is not moving substantially, but a high degree of spinal stability is required so that the shoulder muscles have a stable base to pull from (Zetterberg *et al*, 1987).

The type of muscle work used to overload the target muscles is important. Stabilising muscles show predominantly type I activity, and so low loads of approximately 30–40% maximum voluntary contractions (MCV) should be used and the contraction held for ten seconds (Richardson, 1992). Fatigue must be avoided as this will encourage the continuous tonic muscle activity to change to bursts of phasic actions giving a 'juddering' appearance. Rapid movements must also be avoided as these have been shown to recruit type II fibres preferentially (Richardson and Bullock, 1986; Ng and Richardson, 1990). In particular, rapid trunk flexion has been shown to favour rectus abdominis activity over that of the oblique abdominals (Thorstensson *et al*, 1985), a pattern unsuitable for lumbar stabilisation.

Finally, specificity of the training response must govern the selection of exercises in late stage rehabilitation. The co-ordinated patterns seen between the abdominal muscles have been shown to be task specific (Cresswell *et al*, 1992). For this reason, if the muscles are overloaded in an attempt to strengthen them, the type of strength gained will reflect the muscle work used. In addition the movement pattern used during an exercise will rehearse and reinforce a sequence of events peculiar to a particular task. Therefore, the selection of exercises in stage 4 of the ALS programme will largely be dictated by the tasks an individual will carry out during daily living.

## Stage 1

The first stage in the stabilisation process is muscle re-education. The muscles responsible for the ALS process must be facilitated as the patient has often lost voluntary control over these, and in many cases stabilising muscle activity is inadequate. In the abdomen it is critical to isolate contraction of the oblique abdominals and transversus abdominis from that of rectus abdominis which is often dominant. In the lower back, action of multifidus will normally be poor at the level of spinal pathology, so facilitation of this muscle segment is important.



## Abdominal Hollowing

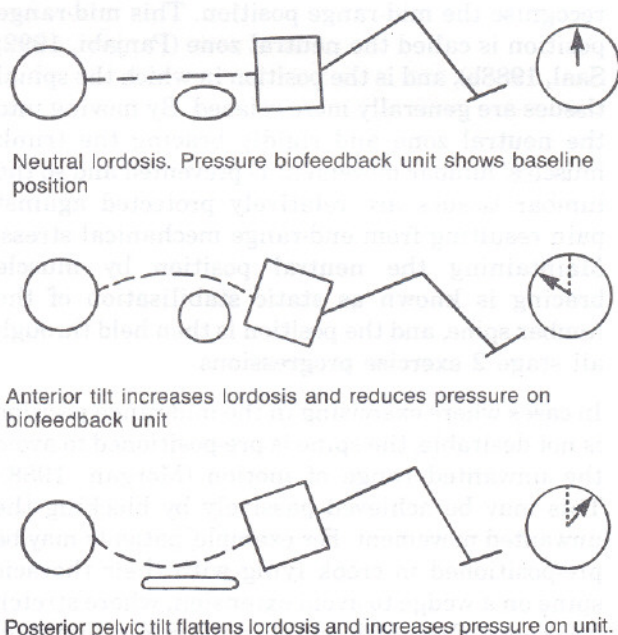
Both dynamic abdominal bracing (DAB) and abdominal hollowing (AH) have been shown to give muscle activity suitable for lumbar stabilisation (Richardson *et al*, 1990). However, most subjects find AH easier to learn, and importantly, this action has been shown to dissociate activity in the internal obliques and transversus from that of rectus abdominis (Richardson *et al*, 1992). This makes the exercise useful for re-educating the stabilising function of the abdominals where rectus abdominis has become the dominant muscle of the group.

Dynamic abdominal bracing (Kennedy, 1965, 1980), is a technique in which patients are encouraged to expand the abdominal muscles laterally. The patients place their hands over the oblique abdominals just superior to the iliac crests. The action is to contract the oblique abdominals and transversus and so press the hands apart, rather than cause the abdomen to protrude by contracting rectus abdominis alone.

In contrast, abdominal hollowing is achieved by patients pulling the abdomen in, without allowing significant lumbar flexion. This is easier if they are asked to focus their attention on the umbilicus, this area becoming a focus for movement control. Patients are instructed to pull the umbilicus 'in and up' while breathing normally. Performing the action from a prone kneeling position eases learning. In this position the abdominal muscles will tend to sag, giving stretch facilitation. As the muscles contract against gravity and pull tight, the patients can feel movement of the abdominal wall. Common errors in the execution of this exercise include holding the breath and practising a valsalva manoeuvre. In addition, patients often inhale and raise the rib cage to make the abdomen appear flatter. Posterior pelvic tilting and depression of the anterior rib cage is indicative of unwanted rectus abdominis activity. Once the correct contraction is achieved, the exercise is progressed for endurance rather than strength, the aim being to prolong the holding capacity of the muscles.

Multisensory cues in abdominal muscle training, to enhance muscle contraction and motor control have been used with success (Miller and Medeiros, 1987). This technique is extremely useful in stage 1 of the ALS programme. Auditory cues can be provided by a therapist speaking to the subjects and giving feedback about performance. Visual cues are given by encouraging patients to look at the muscles as they function, and by using a mirror. Kinaesthetic cueing is accomplished by encouraging subjects to 'feel' the particular action, for example asking them to 'feel the stomach being pulled in'. Tactile cues are provided by the therapist touching the patient's abdomen as muscle contraction begins.

Restoration of the abdominal hollowing mechanism can also be enhanced by the use of pressure biofeedback (Chattanooga Group Limited, Bicester, UK). The biofeedback unit consists of a rubber bladder and pressure gauge similar to a sphygmomanometer. In the crook lying position, the bladder of the unit is placed beneath the subject's lumbar spine and inflated to show a constant figure of 40 mm Hg. The subject is instructed to contract the abdominal muscles without performing a posterior pelvic tilt (fig 1).



**Fig 1: Use of pressure biofeedback to assist in recognition of pelvic tilt**

If the lordosis is unchanged, a constant pressure is shown on the pressure unit. Increasing pressure shows flattening of the lordosis (lumbar flexion) while reducing pressure shows an increased lordosis (lumbar extension). Excessive motion in either direction represents loss of lumbar stability. Excessive motion in either direction represents loss of lumbar stability. Practising AH from a variety of starting positions, with the addition of simultaneous limb movements encourages body awareness and movement control.

## Multifidus Facilitation

Restoration of multifidus activity begins by facilitating the muscle at the level of spinal pathology, as localised dysfunction of this muscle is common. Low-load rotatory resistance is applied to the affected segment in a side lying position as though testing for passive physiological intervertebral movement (Maitland, 1986). The patient is encouraged to maintain the submaximal contraction against the therapist resistance to rotation applied to the spinous processes.



## Stage 2

Successfully 'bracing' the trunk muscles means that the patient is beginning to maintain static stability of the lumbar spine. Progression can now be made to the second stage of the programme, when the aim is to impose load on to the trunk while maintaining the statically stabilised posture. The trunk should not move. The patient must be able to recognise when the spine is losing stability to be able to correct this. At this stage, passive pelvic tilting is introduced to enable the patient to recognise the mid-range position. This mid-range position is called the neutral zone (Panjabi, 1992; Saal, 1988b), and is the position in which the spinal tissues are generally more relaxed. By moving into the neutral zone and rigidly bracing the trunk muscles, lumbar movement is prevented and so the lumbar tissues are relatively protected against pain resulting from end-range mechanical stress. Maintaining the neutral position by muscle bracing is known as static stabilisation of the lumbar spine, and the position is then held through all stage 2 exercise progressions.

In cases where exercising in the mid-range position is not desirable, the spine is pre-positioned to avoid the unwanted range of motion (Morgan, 1988). This may be achieved passively by blocking the unwanted movement. For example, patients may be pre-positioned in crook lying with their thoracic spine on a wedge to avoid extension, where stretch weakness of the abdominals determines that only inner range movements should be worked. A lumbar roll may be used to avoid flexion where this is required. Active pre-positioning is achieved by placing the patients' lumbar spine in the desired position and instructing them to hold this position rigidly with muscle activity alone.

The crook lying position used for AH in stage 1 is progressed by using leg and arm movements to impose load on to the trunk. Maintaining the neutral position, the heel slide is performed. From crook lying, one leg is straightened while keeping the heel on the ground and sliding the leg into extension. This may then be progressed to single leg raising while maintaining the neutral position. Overhead arm movements are introduced. Stage 2 continues by gradually increasing the overload on the stabilising muscles through a series of progressive exercises which follow a neurodevelopmental pattern of posture control (Saal, 1988b). Tasks begin in prone lying, supine lying, and side lying positions. Later they move to prone kneeling, high kneeling, sitting, lunging and finally standing.

Stage 2 work emphasising the oblique musculature and multifidus is achieved by using rhythmic stabilisation (RS) techniques in various starting positions. Side-lying activities are useful to develop

the endurance capacity of the trunk rotators. In crook side lying the therapist pushes forward on to the subjects' pelvis and backwards on to their shoulder while the subjects resist the action (fig 2).



Fig 2: Rhythmic stabilisation

The movement direction is then reversed. In crook lying the therapist pushes against the patients' bent knees trying to cause spinal rotation, while the subjects resist this movement (fig 3). Patients

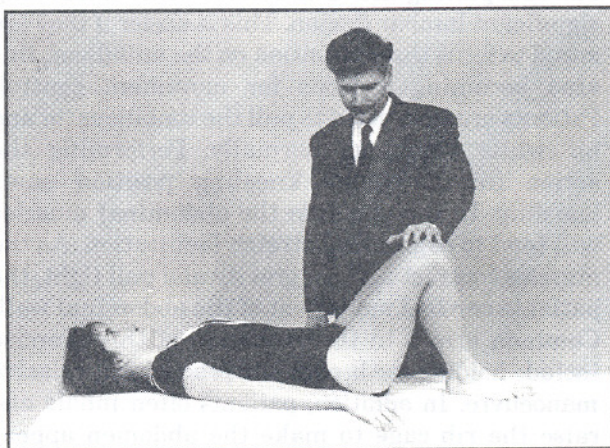


Fig 3: Developing trunk rotator strength

can continue this activity as a home exercise by pushing against a foam cushion or soft ball secured against a wall (fig 4). In kneeling, the therapist attempts to push the patients off balance by displacing their centre of gravity while the patient

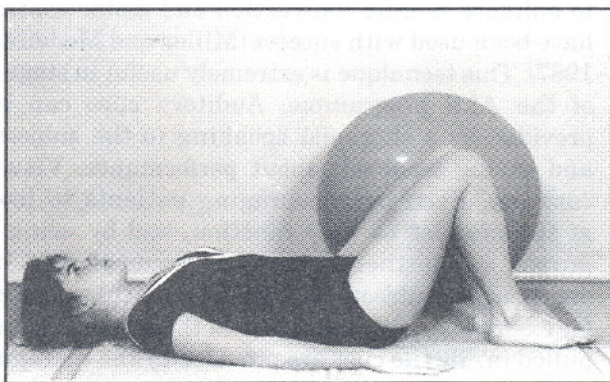


Fig 4: Home exercises — trunk rotation





**Fig 5: Maintaining lumbar stability during balance activities**

resists the action (fig 5). The direction of the push dictates the muscle action.

Static work on the spinal extensors to develop endurance may begin in prone falling and prone kneeling positions. In prone falling the patient is positioned with the upper body over the end of the couch with the hands on the ground. The patients' legs are supported, and while maintaining the neutral spinal position first one arm and then the other is lifted clear of the ground. The aim is to maintain the stabilised neutral position against gravity initially for ten seconds, progressing to 60 seconds. From prone kneeling, the feet are fixed and the patients sit back on to their ankles. The arms are lifted from the ground and the trunk held at 45° to the horizontal. Holding time is progressed while maintaining a neutral spinal position.

Bridging activities elicit a co-contraction between the abdominal muscles, the spinal extensors and the hip extensors. They therefore achieve muscle activity patterns associated with lumbar stabilisation (Richardson *et al*, 1990). One such exercise is performed as follows. From crook lying the patients are lifted up into a bridge position. The patients then try to rotate their pelvis to the right while the therapist resists the rotation by applying pressure through the left anterior superior iliac spine and the right posterior iliac crest. The exercise direction is then reversed.

Static stabilisation may be combined with stretching exercises for tight muscles identified on muscle imbalance assessment (see previous article). Active stretching for the hamstrings, iliopsoas, and ilio tibial band (ITB) may all be performed while maintaining a neutral position of the lumbar spine. The proximal attachment of these muscles to the

pelvis means that they will tend to tilt the pelvis when a stretch is imposed on them. The overload for maintenance of neutral position by the trunk muscles is therefore provided by the hip muscle stretch.

### Stage 3

The pelvic tilting action now changes from the passive procedure in stage 2 to identify mid range to an active exercise to teach control throughout range. The patient must be encouraged to use the lower abdominals and hip extensors in combination, rather than the hip extensors alone, to perform the posterior pelvic tilting action. Palpation and body awareness exercises are used to help the patient isolate contraction of one set of muscles from the other.

Pelvic tilting is used to identify which portions of the patient's total range of motion are symptom free and when, during range, pain occurs. The pain-free region within the movement range has been termed the 'functional position' or 'safety zone' (Morgan, 1988; Paris, 1993). The exact range of symptom-free motion, and the position of this portion within the total range of motion, will depend on the patients' spinal pathology. Patients with acute disc lesions, for example, may need to avoid flexion, while those with spinal canal stenosis might need to avoid extension. As treatment progresses, the size of the functional range may increase, and it may move closer to the mid-range position (Morgan, 1988).

To achieve the required degree of voluntary control over pelvic tilting actions, patients must develop sufficient body awareness to be able to feel when the lumbar spine begins to move away from the functional position. When awareness has been gained, control of the new movement is sought (Miller and Medeiros, 1987). To do this, kinaesthetic perception must be improved, and this is achieved by performing the pelvic tilting action in a variety of starting positions, and through a variety of ranges.

When the patients have gained sufficient voluntary control of pelvic tilting to be able to avoid end range tissue stress and remain within their functional zone, the stabilisation process has progressed from static to dynamic.

Dynamic stabilisation exercises use many of the starting positions and progressions of stage 2. In stage 3, however, pain-free movement is allowed and the patients are encouraged to 'explore the motion of their lumbar spine'. Flexion and extension movements may be performed in prone kneeling (humping and hollowing) and rotation actions in high kneeling, sitting and standing. The use of weight pulleys and elastic rubber tubing to add resistance to the movements is helpful.



## Proprioceptive Training

One of the arguments for using proprioceptive training as part of a spinal rehabilitation programme is that in a highly mechanised Western society the variety of movements which an individual regularly undertakes is considerably reduced. This reduced movement 'vocabulary' decreases the proprioceptive stimulation needed for skilled motor action (Jull and Janda, 1987). After injury, proprioceptive input is further reduced due to prolonged inactivity. Therefore, in addition to restoring strength and flexibility of the trunk following injury, it seems logical to use complex skilled trunk actions to redevelop balance and co-ordination skills.

The use of proprioceptive stimulation, by employing skilled movements, is well documented during the rehabilitation of ankle injuries (Freeman *et al*, 1965; Lentell *et al*, 1990; Konradsen and Ravn, 1990) and is increasingly recognised as being beneficial during the rehabilitation of the anterior cruciate ligament (ACL) deficient knee (Barrack *et al*, 1989). The functional importance of proprioceptive training has also been emphasised during rehabilitation of the spine (Lewit, 1991), although its use in spinal rehabilitation is less common.

Aspects of proprioceptive training (table 2) can be incorporated at any stage of the ALS programme. Training begins by splitting complex movements into a number of simple component sequences. Many of the exercises used have already been described in stages 2 and 3, but the choice of exercise is determined by the functional requirements of the patient. Actions must be slow

and precise with the emphasis on control of the correct body position. The rate of movement is progressed, while maintaining accuracy, and the simple movement components are linked together to form the total activity sequence (Tropp *et al*, 1993).

Once an action can be performed correctly on a stable surface, the subject is positioned on a moving base of support. Initially the labile surface is supplied by a rocker board with the subject sitting or in high kneeling. Placing the pivot of the board in the frontal plane will work flexion and extension reaction, while placing the pivot in the sagittal plane will work lateral flexion. The pivot is then placed diagonally to combine these movements, and progression is made to the wobble board where the pivot point is dome shaped to increase the variety of movements. Other apparatus useful for balance work and muscle reaction includes the large diameter (65 cm) gymnastic ball, the mini-trampoline, the Fitter ski-training device (Fitter International Inc, Calgary, Alberta, Canada) and the 'slide trainer' (Forsa Fitness Equipment, London). In each case, as the patient is pushed off-balance, the aim is to maintain lumbar stabilisation.

## Use of the Gym Ball

The 65 cm gym (Swiss) ball is an inexpensive and useful piece of apparatus suitable for stabilisation exercises in stages 2 and 3. The ball can also be used to facilitate dynamic balance and posture control in cases where movement dysfunction is present, and in normal subjects where the aim is prevention (Irion, 1992; Lester and Posner-Mayer, 1993).

Various sizes of ball are available, and the subject should be able to sit with the knees and hips flexed to 90° and the feet flat on the floor. From this position patients are taught to find their functional position by rolling forwards and backwards on the ball. If the shoulders are kept in the same starting position, the rolling motion of the ball will cause a pelvic tilt, flexing and extending the lumbar spine. When in mid-range, initially stage 2 isometric trunk activity is encouraged by using PNF, including slow reversal hold (SRH) and rhythmic stabilisation (RS) techniques. The exercise is progressed as the point of application of therapist resistance moves distally. Initially contact is with the chest and trunk, moving out to the shoulders and then the arms held out to the side and finally held overhead. Stage 3 exercise may be used at home by maintaining lumbar stability and performing pelvic circles. Arm and leg movements may be added later in single and then multiple planes. Balance becomes more difficult when the subjects' attention is taken away from the

**Table 2: Proprioceptive training**

### **Increase awareness of correct pattern**

Split complex movement sequence into simple components.  
Increase awareness by passive movement using multisensory input.

### **Gain voluntary control of movement pattern**

Use multisensory stimulation during demonstration and performance of exercise.  
Start with slow precise movements.  
Stop exercising when patient becomes fatigued.  
Continually correct movement pattern passively.  
Progress exercise only when movement pattern is correct.  
Patient must perform independently before proceeding to more advanced actions.  
Link simple tasks to form more complex actions.

### **Gain automatic control of movement**

Progress speed while maintaining accuracy of movement.  
Perform multiple repetitions of movement sequence.  
Perform actions with other body parts while maintaining accurate stability in the affected body part.



stabilisation task by actions such as writing their name in the air with their hand or foot. Final progressions include the same exercises with the eyes closed.

From a sitting position, the abdominal slide may be performed (fig 6) where the subject performs a

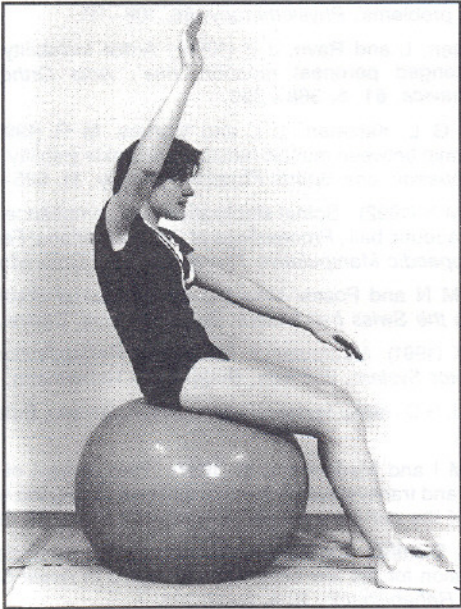


Fig 6: Abdominal slide

backward tilt of the pelvis by tightening the lower abdominals, and rolls back so that the ball rests beneath the lumbar spine. This position may be held and diagonal arm and trunk actions performed against resistance (rubber band) to increase oblique abdominal action. Bridging actions are performed with the ball positioned between the scapulae. Arm and leg actions are again performed while maintaining lumbar stability. Bridging may also be performed by beginning in a crook-lying position with the ball beneath the lower leg. Initially, isometric abdominal hollowing is performed and held while the legs are extended to move into the bridging position (fig 7). Later, an automatic stabilising pattern is sought by moving into and out of bridging without first 'setting' the abdominals. Work is increased for the hip extensors by placing the ball beneath the lower leg and using single leg movements.

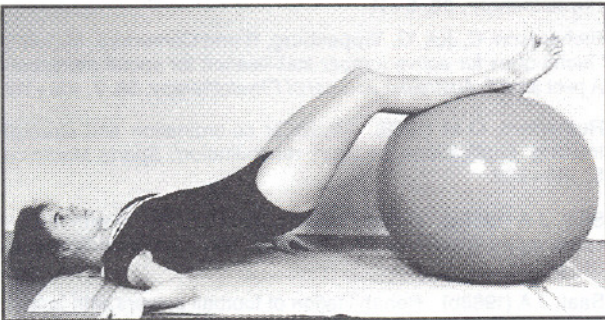


Fig 7: Bridging activities

Prone kneeling over the ball is important because in this position the subjects' lower spine is supported and unlikely to move into hyper-extension. By rolling over the ball and lifting the legs, they move from the prone kneeling position into prone falling (fig 8).

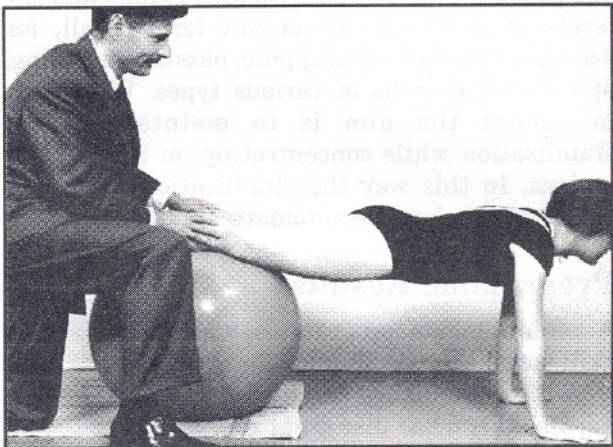


Fig 8: Bridging activities using a ball — prone falling

### Stage 4

To be totally effective, physical training must take account of the SAID principle (specific adaptation to imposed demand). Put simply, this maintains that any change in the body (the adaptation) will closely match (be specific to) any activity performed (the imposed demand). In the case of resistance training this can be highlighted by joint angle specific changes during isometric training and speed specific changes during isokinetic training, for example (Sale, 1992). One of the major benefits of training the musculoskeletal system is learning to co-ordinate the different muscle groups involved in an exercise so that muscles may be appropriately activated (Sale, 1988). Strength training of isolated muscle groups is not the most effective method of increasing functional ability. Instead, the training should involve task-related practice (Rutherford, 1988).

By applying the specificity principle to spinal stabilisation, it becomes clear that the lumbar stabilisation pattern produced during rehabilitation must closely match the tasks which will be performed in patients' daily living. To encourage this, actions are chosen which resemble as closely as possible the functional activities they use daily. These are then employed as exercises in the rehabilitation programme. The exercises are performed to repetition and progressed in exactly the same way as any other exercise would be. Correct technique is essential, and no pain should be experienced as this will tend to reinforce faulty movement patterns (Irion, 1992).

Specific exercises may be linked together in a



circuit training format. Examples of functional circuits include lifting circuits in occupational health physiotherapy and technique specific circuits in sports physiotherapy. The lifting circuit includes a variety of manual handling procedures such as single- and double-handed lifts with a variety of different shapes and weights, pushing and pulling activities, and reaching to high and low levels. A sport specific circuit for football, for example, may include trapping, passing, dribbling, and shooting skills of various types. With each movement the aim is to maintain spinal stabilisation while concentrating on the general actions. In this way the stabilisation process is encouraged to become automatic or 'second nature'.

## Programme Results

A rehabilitation programme which emphasised skill based exercise therapy for the spine has been shown to be effective in the treatment of a herniated lumbar disc (Saal and Saal, 1989), and in the rehabilitation of football players with back injury (Saal, 1988a, b). The programme aimed to restore automatic control of muscular stabilisation of the trunk by teaching the subject to maintain a corrected lumbar-pelvic position while performing progressively more complex tasks.

Use of a gymnastic ball to enhance spinal stabilisation has also been described (Lester, 1992). Eleven exercises were performed during a 20-minute programme, over a seven-month period. Use of the ball was claimed to increase patient compliance to home exercise.

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