Specialist Forum

Problem solving in specific motor control exercise rehabilitation

Sean GT Gibbons BSc (Hons) PT, MSc Ergonomics, PhD (c)

Clinicians are constantly being challenged to problem solve in their clinical practice. A unique aspect of this comes into play when teaching clients specific motor control exercise, which involves specific movement patterns or isometric contractions of specific biases towards certain muscles.

Muscles are required for the control of segmental translation, control of posture and control of movement (Hodges 2005). Motor control is simply the strategies used by the central nervous system to control these along coordination and with skilled actions (Shumway-Cook and Woollacott 2011). There is growing evidence to support the use of specific motor control exercise (Gibbons and Clarke 2009, Gibbons and Newhook 2011). These type of exercises represent two sub-components of core stability exercise (see Gibbons 2007a).

Often the success of teaching people these exercises depends upon the skill and experience of the clinician (in the problem solving strategies used), effective communication and the ability of the client to learn. The environment and other factors may also influence this. The Motor Control Abilities Questionnaire was a questionnaire developed to identify people who could and could not learn specific motor control exercise. It consists of questions that primarily deal with neurocognitive and sensory deficits. New research shows that as many as 8% acute low back pain (LBP) and 19% chronic LBP subjects may have significant neurocognitive and sensory deficits and be unable to effectively learn these exercises (Gibbons 2009). Approximately 20% learn the exercises very quickly, however the group in the middle (approximately half) require the clinician to help them with problem solving strategies.

The purpose of this paper is to describe a problem solving model that may aid the clinician in teaching clients various forms of motor control exercise. Figure 1 illustrates the categories of problem solving that can be used and Table 1 highlights the strategies that may be employed. Table 2 describes some exceptions to these strategies. This will be illustrated by an example of the 'neutral' lumbo-pelvic spine. The neutral spine has become somewhat controversial in rehabilitation. It is not the purpose of this article to debate this topic. In brief, this controversy may exist for several reasons. Research in normal subjects in sitting show that most subjects were unable to achieve a short (neutral) lordosis (Claus et al 2009); it is generally considered non functional to stay in one position (and the belief that a neutral spine is one specific position); subjects without LBP tend to move more and are therefore not in a 'neutral' position (Fenety and Walker 2002, Mok et al 2004); epidemiological studies do not support an association between spinal curves and pain (Christensen and Hartvigsen 2008); there is confusion over the concept of the neutral zone put forth by Panjabi (1992) which considers the translation of a joint segment (and related to spinal instability) and the neutral spine position, which relates to the alignment of a spinal region.

A deeper understanding of movement, motor control and sensory motor function shows the short comings of these issues in a debate. There are some points to consider before discounting this type of rehabilitation. Subjects with non specific chronic LBP tend to spend more time closer to their end ranges (O'Sullivan et al 2003) and extended time at end range may reduce proprioception (Dolan and Green 2006). As well, staying stationary with increased stiffness may place more stress on the spine (Hodges et al 2009). This discounts the above argument that subjects with LBP move more and are thus not in neutral. If Panjabi's model (1992) is applied, this may be especially true when the spine is at end range. There is laboratory and clinical evidence of the benefits of using the neutral spine position. Some subjects report a lower sense of effort, report greater confidence in learning and have less superficial muscle activity during specific motor

We should be able to make any exercise harder or easier based upon these variables

Table 1: Variables used to modify specific motor control exercise in clinical problem solving (using the example of a specific motor control neutral in supine crook lying).

Variable	Description & Points of interest	Clinical Example to make the neutral lumbo-sacral spine easier
Sensory motor function	Consists of sensory (vision, vestibular, auditory, olfactory, gustatory, tactility) and motor (muscles, fascia, joints, ligaments and skin). Motor feedback provides proprioceptive and kinaesthetic sense.	Tactility: monitor the rib cage during anterior pelvic tilt to avoid a thoraco-lumbar lordosis
Load	The load of a movement may be modulated by: lever size, external load, friction, gravity, external load, buoyancy	Friction: lie on a smooth surface to allow the gluteals to slide
Range of motion (ROM)	Inner range and outer range influences the force efficiency of a muscle and influences the stretch of passive structures for sensory feedback. Global stability muscles may be more efficient in outer range. With certain movements, there will be a larger load on a body part due to the position of the limb against gravity (e.g. 90° shoulder flexion).	Outer range: start in full flexion and move into extension from this position
Neurocognitive function	Consists of various cognitive functions such as: concentration, memory, attention, problem solving, decision making.	Clear background noise, dim lights and use meditation and mental imagery strategies for focus. This strategy can be made harder by adding tasks such as: counting backwards by 3, recounting directions or a grocery list
Acceleration	The rate of change of velocity over time. It describes the rate of change of both the magnitude and the direction of velocity	Accelerate slowly (use cues such as cold maple syrup or molasses pouring)
Base of support	A base of support can be decreased in size, unstable, movable or have reduced sensory input	Use a firm base of support. Increase base of support by abducting hips.
Movement facilitation	A group of strategies that may be used to facilitate movement or muscular contractions. Motor facilitation: closed chain exercise, associated movements, postural reactions, gym ball movements Motor Sequencing: Modify the sequence of motor commands for a task Unload restrictions to movement: modify a position to take a tissue structure off load to increase movement Control of secondary movement pattern control deficit: active or passively control proximal or distal stability Change position: move to another position for ease of pain, stiffness / restriction, or familiarity or safety Safety & confidence: modify position / surroundings to reduce fear and improve safety.	Unload restriction: Abduct the hips to unload superficial gluteus maximus and the hip joint. *In sitting:* *Unload restriction: raise the seat height and abduct the hips* *Motor facilitation: lift the thoracic spine and then anterior tilt or reverse cues* *Control of secondary movement pattern control deficit: support the thoracic spine with a back to the seat or with co-contraction with protraction of the scapula (hands on the desk).*
Endurance	Endurance is the ability to hold a static position the ability to continue the same task (e.g. repetitions) without a loss of performance	Start without an isometric holding time and just do several repetitions.

control stability exercise in the neutral position (Gibbons et al 2002) and there may be increased (and unwanted) superficial muscle activity during specific motor control exercise when out of neutral in some subjects (Sapsford et al 2001, Gibbons et al 2002).

It should be appreciated that achieving a neutral spine position is primarily a function of superficial or 'global' muscles. The deeper 'local' muscles play a smaller role in producing physiological range of movement. A further description of muscle classification can be seen elsewhere (Gibbons and Comerford 2001). Achieving a neutral spine should be regarded as an element of movement pattern control. This is relevant because subjects with chronic LBP move their spine greater than their hips during trunk flexion compared to subjects without LBP (Gibbons 2011a). For example, anterior pelvic tilt to neutral is relative extension of the spine if the starting position is flexion.

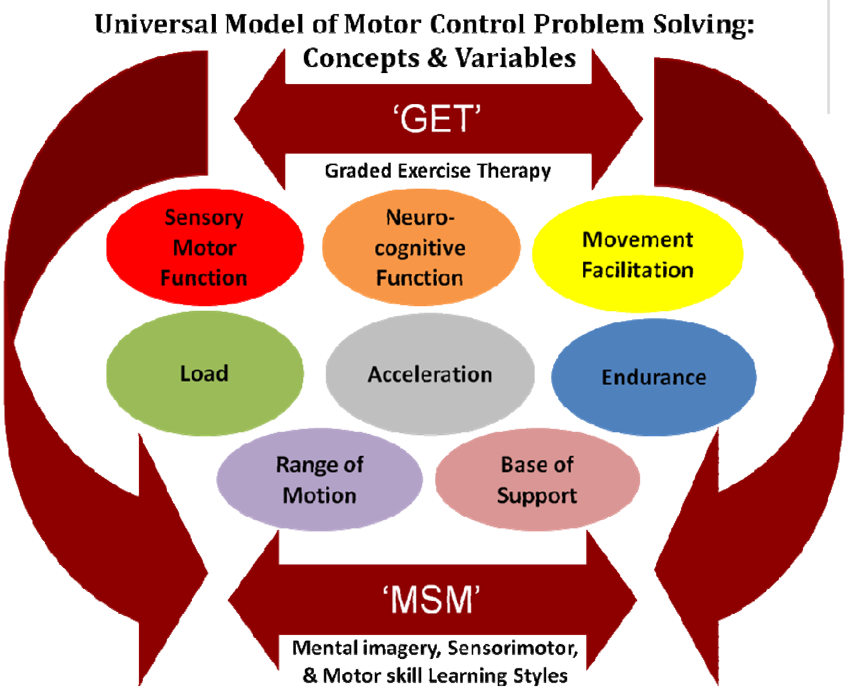


Figure 1: Variables that can be used to modify specific motor control exercise during problem solving to make the exercise easier or more challenging.

Therefore, a neutral spine has the potential to help control movement. One clinical trial provides preliminary evidence of a clinical benefit (Suni et al 2006). Another clinical trial with acute low back pain found a neutral position was able to provide pain control in subjects (Gibbons 2007b).

The neutral position may be defined as a region in which the joints and surrounding passive tissues are in elastic equilibrium and thus in a position of minimal joint load (McGill, 2007). This should not be confused with a neutral spine position in the lumbo-pelvic position. There is some disagreement about what is 'ideal' posture (Claus et al 2009). This may be because a 'neutral' posture or position is different for each individual*. There is also the influence of how one achieves a neutral position. For example, if the larger spinal global mobilizer muscles (e.g. iliocostalis and longissimus) dominate an anterior pelvic tilt, there may be more of a thoracolumbar lordosis and less of a lumbo-sacral lordosis. This clinical observation requires quantitative analysis. Both movements of anterior pelvic tilt may create a 'neutral' position, but the thoraco-lumbar lordosis should not be considered ideal. As well, this movement pattern is not as effective at reducing pain (Gibbons 2007a). Further, the larger global mobilize muscles have large attachments to the rib cage and when contract excessively can have a deleterious influence on breathing.

For the purposes of this article a neutral position may be considered a region midway between an individual's end range position of a joint, or in the case of the spine, the anatomical postural region, that is actively gained by biasing the global stabilizer muscles to achieve this position and held with minimal muscle activity and with normal breathing. It is critical to emphasize that this is not

Table 2: Exceptions to the variables used to modify specific motor control exercise in clinical problem solving

Variable	Exception
Sensory motor function	Some individuals are able to concentrate more with their eyes closed. In most clients and tasks, taking away oculomotor function makes an exercise more difficult
Load	Normally increasing a load will make an exercise harder, however in some clients this provides more sensory feedback and can make an exercise easier
Acceleration	Sometimes moving a limb faster makes the exercise easier rather than harder. This may be because the golgi tendon organ acts as a source of proprioceptive feedback when the muscle spindle does not provide adequate sensory motor feedback.

an exact position, but rather a variable range depending on the individual's available movement. This mid range position is important because stability and proprioception is required from myofascial structures (active mechanisms) rather than ligaments and capsules (passive mechanisms). The range of neutral can also change during the course of rehabilitation if more movement is gained.

Our clinical observations and laboratory findings suggest this strategy results in a better clinical neutral position. To distinguish a general neutral position from the conscious control of the ideal movement pattern biasing the global stabilizer muscles, it may be more appropriate to use the term 'specific motor control neutral'. This would fit in line better with the other terms used in the core stability spectrum of exercises (Gibbons 2007b). For simplicity, this will be referred to as 'specific neutral' for the rest of this article.

The instructions by the clinician to the client in how to achieve the desired movement, or 'cues' are highly variable depending on what is meaningful to the clinician and the client. Common cues usually relate to the most efficient learning style of the client. It is generally accepted that the key learning styles include: auditory, visual, and kinaesthetic / tactile (Fleming 1992). The latter three are commonly employed in specific motor control rehabilitation. Learning style categories may be better considered to be mental imagery, sensorimotor and motor skill to address the more recent advances in learning and neuroplasticity (Gibbons 2011b). People may not be able to understand what learning style they have since it may be a blend of all three. It may be best to problem solve as described below.

It is common to start training the lumbo-pelvic specific neutral region in supine crook lying since the spine is relatively unloaded and this position is often used for pain control in clients with LBP. The flexion of the hips will usually (but not always) create relative spinal flexion so the cues to start here will be related to creating anterior pelvic tilt. Both directions may need to be performed in order to let the client know where "mid range" is. The cues depend on the individual's perception so if they perform posterior pelvic tilt simply use the opposite cue. Table 3 lists common cues used in teaching a specific neutral region. The latter cues are only generally used when the client's understanding and ability is low.

Table 3: Common cues used in achieving a specific neutral region

Common verbal cues
Tip your tailbone forwards (up) / backwards (down) Tip your pelvis forwards (up) / backwards (down)
Roll your hips forwards / backwards Place (tip) your tail between your legs and towards the back of your head
Imagine the four corners of the pelvis as a bucket and tip the bucket Slide your bottom towards your head and your feet
Arch and flatten your back Lift off and flatten your belt line
Imagine riding a horse or a bike and you have to sit up straight Imagine a slightly sharp object moving up from the bottom of your back and you have to move away
Place a hand or face cloth (flannel) under the lumbo-sacral junction and move into it or away from it Tip the head backwards and push heels into bed

Caution should be used here and the client should be suspected of being unable to learn the exercise, which is a CNS Coordination deficit (Gibbons 2011c).

Visual processing: Oculomotor Function, Visual Feedback and Visual Learning

Terminology relating to "visual" descriptions deserves some extra commentary since these seemingly overlapping concepts may be confusing. (1) The oculomotor system has twenty functions to relay the central nervous information about our surroundings, however we are usually only familiar with visual acuity. We can use this oculomotor information to obtain feedback about our environment, our movement, our posture and stability. (2) This is the essence of using visual feedback such as a mirror or real time ultrasound biofeedback or graphical displays with electromyographic feedback. In the example above, the client can watch themselves in a mirror or a pressure biofeedback (see below). (3) A visual learner prefers to receive information through the oculomotor system in order to process it effectively and achieve a skill or store information to later receive it. In this case, they can watch the clinician perform a specific neutral task.

Graded Exercise Therapy & Learning Styles

Graded exercise involves continually improving exercise and activity tolerance utilizing a quota system instead of pain abatement (Fordyce et al 1973). These principles may need to be used in some individuals. This may be due to concerns regarding pain provocation, extreme fatigue or as a general precaution.

Learning styles have been introduced above. Ideally, the teaching and cueing methods would consider the client's learning style. Most people will have a variable combination of sensory motor learning styles. The ideal learning style is mental imagery (Gibbons 2005). Mental imagery is the ability to perceive an experience that normally requires sensorimotor information or movement, in the absence of the appropriate stimuli. We are more interested in motor imagery (the mental representation of movement without any body movement) in teaching specific motor control exercise. When using motor imagery it is important to ask the client if they are imagining themselves perform the task while inside of their own bodies or if they are imaging watching their self or someone else perform the task. The former is internal motor imagery and the latter two are external motor imagery. Internal mental imagery is associated with better neuroplasticity. Not all people have the ability to perform mental imagery effectively (Dickstein and Deutsch 2007). As a guide, if mental imagery strategies are not effective, sensory motor strategies can be attempted. If these do not work, motor skill tasks can be attempted. Motor skill involves manually facilitating the desired movement with the client and repeating until they can accomplish without the operator. This will almost always require sensorimotor feedback. It should be appreciated that multiple learning strategies and sensory organs are used by individuals simultaneously however one strategy will usually dominate.

Further example – postural stability

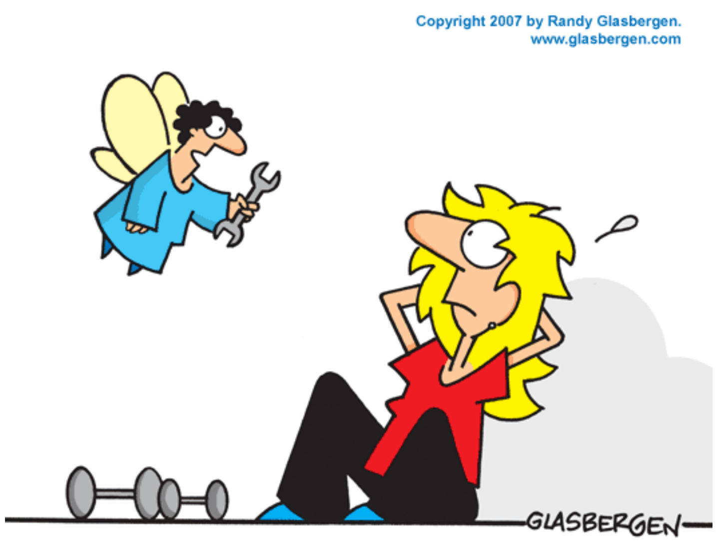
Many of us have been taught to regain proprioception of the leg following a sprained ankle by standing on one leg, closing the eyes and / or standing on a wobble board. Based on the model, we can break this down further. First, this is postural stability, not proprioception, although good sensory motor function is required for good postural stability. Second, when we stand on one leg we are reducing our base of support and a wobble board is using an unstable base of support. Third, when we close our eyes, this is essentially taking away oculomotor function. There are many other ways to challenge this type of exercise requirement. For example, postural stability can be challenged in the Rhomberg or Tandem Rhomberg positions. A useful starting point to challenge oculomotor function may be to ask the client to look side to side (i.e. move the cervical spine and eyes together). We accept that this challenges cervical proprioceptive information and oculomotor function together, however this is arguably more functional (scanning their environment) than having the eyes closed. Smooth pursuit movements, eye stabilization tasks may be used as well. The body can be perturbed by more natural mechanisms such as catching a ball or pendular swinging of the limbs instead of an unstable base.

Integration into function

Training of a specific neutral region is started in a non functional position is started and then gradually progressed into function. This position allows a motor control skill to be acquired. It is often very difficult to start training specific patterns while in loaded or functional positions.

Proprioception & Kinaesthesia

This exercise is easily modified for lumbo-pelvic proprioception and kinaesthesia. The goal is to achieve a lumbo-pelvic neutral position and return there (proprioception: repositioning sense). A pressure biofeedback unit can be used to monitor the starting position. If the client uses the force as feedback rather than the position in space they can use the exercise to match the force (kinaesthesia). These exercises may be performed using a specific neutral region or a traditional neutral.



"I'm the Workout Fairy.
I'm here to tighten your abs!"

Conclusion

A model has been presented that presents problem solving strategies for most exercises in specific motor control rehabilitation and a specific neutral region of the lumbo-pelvic region has been used to help illustrate the concept. The variables can be adapted to make exercises easier for the client or more challenging. They can also be combined together to create numerous challenges for the client. It should be appreciated that this type of rehabilitation is meant for people with only motor function deficits. It is not recommended for those with psychosocial or psychological risk factors for poor outcome, clients with a central sensitization pain mechanism or central nervous system coordination deficit (Gibbons 2011). These should be ruled out using appropriate screening methods prior to commencing to this type of rehab.

* Note: We would like to acknowledge that some of the earlier ideas regarding the concept of the ideal neutral region were done in collaboration with Mark Comerford. The concept that evolved into 'specific motor control neutral' was done independently.

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Clinical Tips

Facilitation strategies for gluteus maximus

Sean GT Gibbons BSc (Hons) PT, MSc Ergonomics, PhD (c), MCPA

There is little doubt that gluteus maximus is a very important muscle for the lumb-pelvic-hip region in mechanical pain disorders. In fact, exercises for gluteus maximus are a key part of some clinical prediction rules for significant improvement for several conditions. As well, we feel that gluteus maximus training rehab is integral to hamstring rehab. We have a large case series for hamstring rehab for rugby players from a Canadian rugby team.

> Gluteus maximus is one of the best & easiest muscles to rehab for a positive clinical effect in mechanical pain

The strategies discussed here are useful when: during standing or prone, there is little or no change in gluteus maximus tone during conscious activation, or there is extreme hamstring dominance during movement pattern