Does ‘core stability’ training improve performance and reduce the risk of injury in football?

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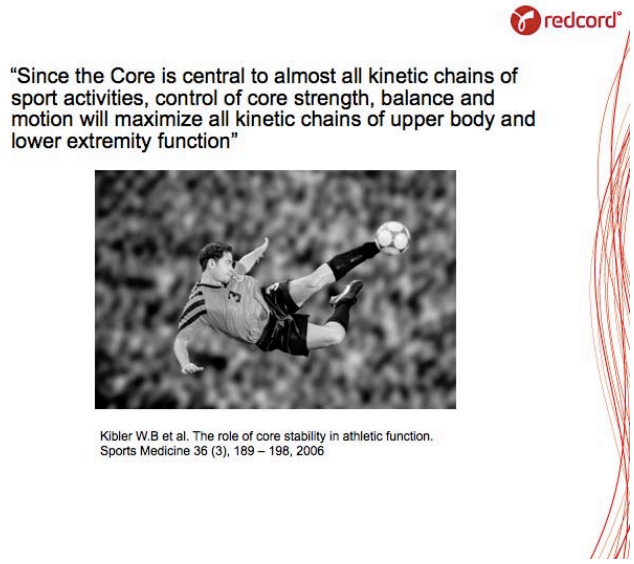
The Core can be considered the pelvic-lumbar-thoracic region with all its bony attachments that make levers for many muscles to act on, as well as connective tissues that possess stiffness to transmit/resist force. The function of the Core is very much dependent on the control mechanisms that monitor and co-ordinate activity in the Core and across the core to the limbs. Optimal function in the Core is a result of an interaction between interdependent active, passive and neurological activities.



Different exercises affect the Core in different ways, and therefore have different clinical and functional outcomes. Something as simple as nutation of the sacrum can affect the entire muscle chain from the hamstrings to the contralateral latissimus dorsi. This is poorly understood and therefore studies on the subject of Core exercises show a variety of outcomes. This is a question of scientific design and validity, not necessarily a reflection of the effectiveness of a certain technique. Asking is Core training works can be compared to asking the question ‘does surgery work?’. This depends on the diagnosis, the specific technique performed and the skill with which it is executed.

Optimal Core function is one of the cornerstones of traditional training systems such as Yoga, Qi Gong and Tai Chi, as well as more modern forms of training and treatment such as Pilates and the Redcord methods (Neurac, Core+ and ActivCore). Many successful athletes have used these methods to enhance performance and rehabilitate following injury. The fundamental reasons for the success of certain specific Core exercises in improving sports performance and reducing the likelihood of injury are as follows;

1. proximal stability allows for distal control. This is a well accepted phenomena by Bobath trainer physiotherapists who work with motor control and dysfunctional movement.

2. the pelvic-lumbar-thorax complex (or Core) is a primary force generator, and a key contributor to summation of forces during large movements. This is well accepted by biomechanists.

3. the centre of mass of the whole body lies in close proximity to the Core. Poor proprioception and control can affect the ability to manipulate dis/equilibrium. Most sports benefit from *agility*, rather than *stability*. This depends on the ability to manipulate the centre of mass and base of support under the influence of external forces.

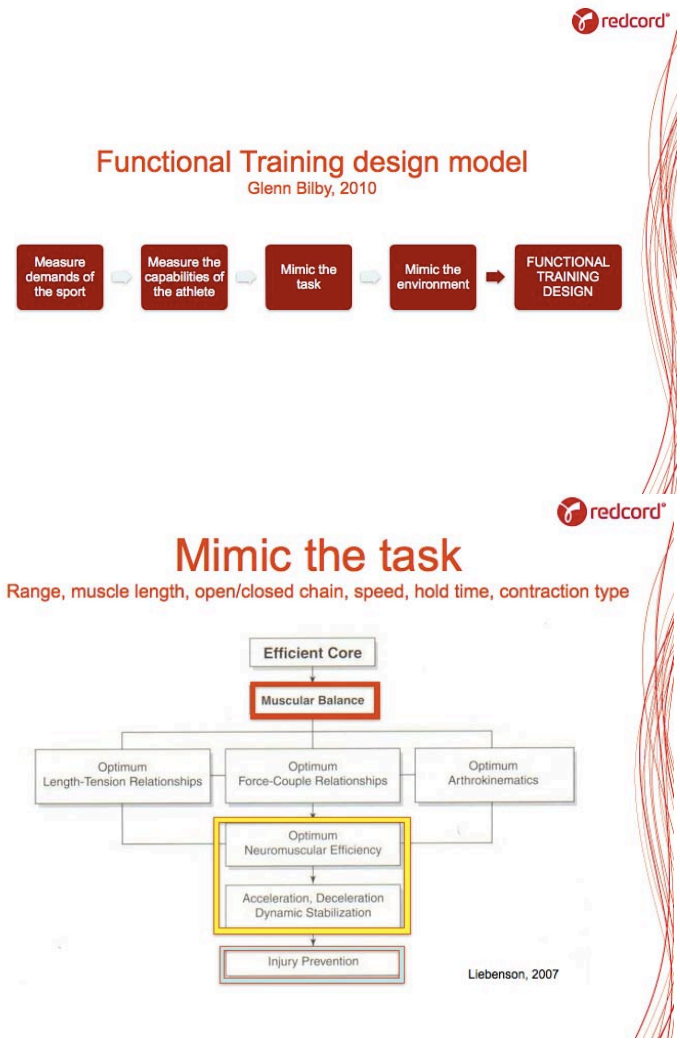
4. posture of the pelvic-lumbar-thorax complex (or Core) acts as an attachment for limbs as well as being a force generator in itself. Posture of the Core therefore affects the strength, stability and stiffness of multiple segments in the kinematic chain. For example inadequate lumbo-pelvic control can cause problems at the lower limb.

5. movements of the limbs are often preceded by a central nervous system initiated 'feedforward mechanism' that subconsciously pre-activates Core muscles within milliseconds of the primary voluntary movement. These muscles can switch off with pain/disuse/fear avoidance, and may not restore to normal once pain is removed. Some studies suggest that specific low threshold core stability exercises may be able to 're-activate' them - increasing performance and reducing the risk of re-injury.

Commercialized health and fitness industries have attempted to standardise 'soft' versions of Core training that promise a magic routine of exercises that suits everyone, with the aim of increasing performance and guaranteeing a pain free back. This is the butcher pretending to be the surgeon - skilled with the knife but not quite sure why she is making the cut. Joseph Pilates would turn in his grave if he knew how oversimplified his methodology had become by copycats professing to teach his lifetimes work in training the Core to participate in optimal movement patterns.

The critical mistake many therapists and trainers make are as follows:

1. assuming that all exercises that look similar to a task are in fact 'Functional' without consideration for the length-tension relationship, force-velocity relationship, posture and the environment.



2. not understanding the forces acting on the body when in different body positions or using different training tools. Balls, balance cushion, balance plate, suspension in ropes, all possess different bases of support, degrees of freedom, moments and materials. Therefore, a similar position can have very different forces acting on it, depending on the external factors.

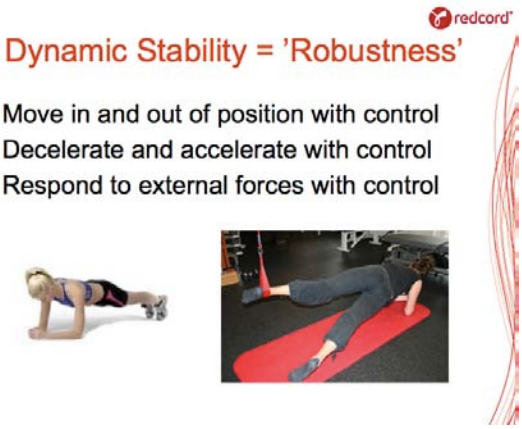
3. assuming that an unstable surface is always best simply because it is more difficult. Standing on a ball or doing bench press on a ball is not always relevant, can activate the wrong muscle groups and can lead to inferior strength gains.

4. assuming that activation of the transversus abdominus muscle by 'hollowing' of the abdomen is the key to Core stability. This simple reduces the moment arm of the powerful oblique muscles and puts them at a mechanical disadvantage, thus weakening the Core.

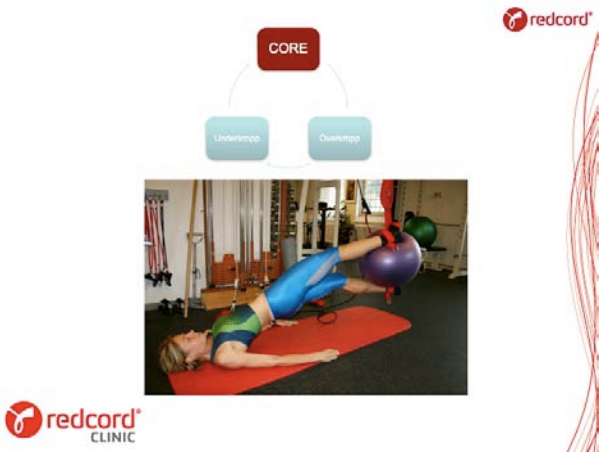
5. assuming that 'the burn' or lactic acid leads to a suitable training effect. Adaptations in intermuscular co-ordination occurs best in the absence of fatigue, especially at high speed.

6. assuming that a strong rectus abdominus leads to increased performance and reduced back pain. This may be responsible for the fallacy that a flat back (created by the action of Rectus abdominus - posterior tilt of the pelvis and some degree of forward tilt of the ribs) protects the back when lifting and performing Core training exercises. Such well entrenched myths are a symptom of copycat 'experts' who presume to know what to do but not why.

7. not challenging timing and sequencing of muscles. Slow, static exercises such as ‘plank’ can interfere with performance. Similarly exercises that are too difficult or are reliant on habitually poor motor patterns can lead to overactivity of agonists that co-contract when they should be relatively relaxed during a movement.

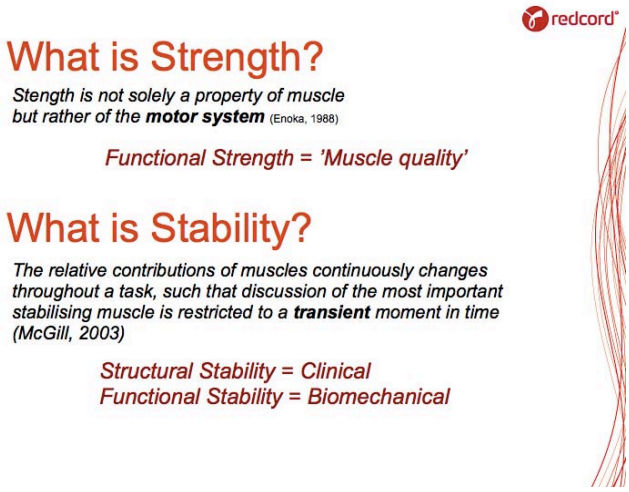


8. training the body in straight lines and formal movement patterns, rather than diagonals and with some degree of perturbation or unexpected external challenge. Acute rehabilitation may justify some machine dominated exercises such as in a ‘crunch’ or ‘back extension’ machine, but typical movement in everyday function occurs in diagonals and involves moving the body’s own mass around its base of support, not just external loads.



Most quality Core training systems are in fact rather complex, progressive and largely dependent on a detailed initial assessment or screening process that identifies strengths/weaknesses in motor control as well as the integrity and performance of muscle-fascia chains. A differential diagnosis arises from exercise testing, and before suitable exercises can be recommended, the demands of any task and the capacity of the tissue to adapt needs to be considered. This is *exercise prescription* at a professional level, rather than simply training or having a workout. The work done is connected to the desired outcome, and musculoskeletal testing/re-testing lends support to the functional findings. It is fair to say that there are many athletes performing well in spite of their therapists and trainers, because they are trapped in traditional methods rather than following the above-mentioned clinical reasoning.

As functions of activity in the Core, *core stability* and *core strength* are not synonymous. Furthermore, training *static stability* in the Core muscles (eg performing 'the plank'), is not the same as training *dynamic stability*. Dynamic Stability involves trunk rotation through range, which is obviously far more relevant for kicking or throwing a ball, but also for running, walking and balancing on one leg.



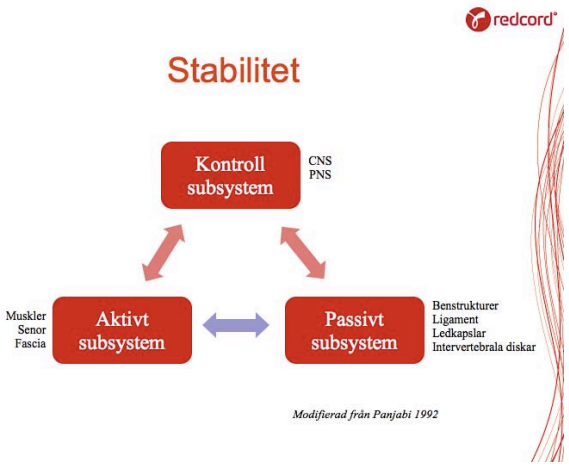
Misunderstandings about what constitutes Core training makes it difficult to find consistent evidence-based support for Core training as a solution to increasing performance and reducing injury. In practice, Core training is not a single technique to be recommended, but a family of exercises from which specific exercises should be chosen. More specific studies need to be

done on individual exercises from the 'family' and compared with more specific tasks within a sport. Attempting to investigate 'does Core training improve football?' is far too ambitious as it introduces too many variables.

Specific issues in current knowledge are:

1. there is disagreement and misunderstanding about the location of the Core and structures involved (eg. SIJ, Thoracolumbar fascia, sacrotuberous ligament, psoas, iliacus, pelvic floor, diaphragm)

2. there is inconsistent understanding about the factors that contribute to core stability (eg. sensorimotor, active stability from muscles, passive stability from joints/ligaments), and therefore different methodologies challenge the Core differently. They cannot really be compared as their mechanism are very different, yet often interacting.



3. stability or resistance to a change in equilibrium may improve on re-testing of the intervention exercise itself (often static), but this is not necessarily transferred to performance (often dynamic). That is, training on a ball increases performance on a ball, but it does not increase sprinting or swimming speed.

4. dosages (reps, sets, %1RM load) vary and therefore physiological responses vary:

    a. Many disagree about the strength gains achieved with sub-maximal or maximal loads. This depends largely on the state of the subject - injured, untrained or trained athlete.

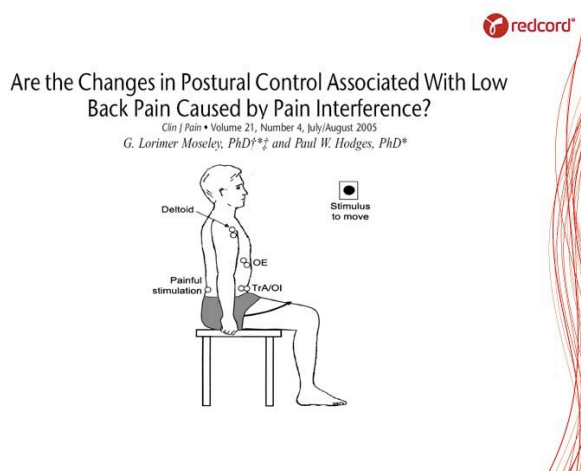
        i. Sub-maximal loads performed slowly challenges muscular endurance rather than absolute strength, and have a bias towards activation of slow motor units and tonic muscles. Jull, Richardson and Comerford have recommended training motor control with loads of less than 35% 1RM, prior to a strength focus with increased

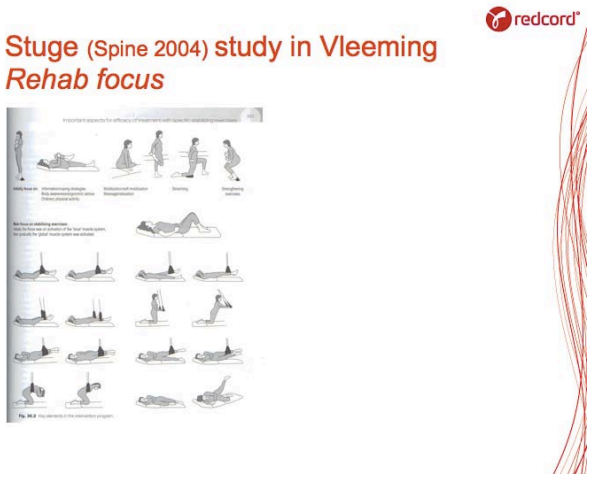
loads. They have also suggested isolated exercises using cognitive strategies to activate the deeper Core muscles, before progressing to more complex tasks and higher loads.

ii. The Neurac and Core+ methods (Redcord, Norway) recommend high perceived effort in order to sequentially increase neural drive to all motor units. Repetitions, hold time and speed of movement are varied depending upon the stage of rehabilitation or the demands of a particular functional task.

b. Lifting weights or standing on a ball, balance board or cushion may be perceived as more 'difficult' than a 1 RM lift, but it will not necessarily increase power or speed in field tests that are stable and explosive. In 'bench press' or 'flyes' on an unstable ball compared to a stable bench, there is increased Core muscle activity but much reduced shoulder girdle activity. One must ask, what is the desired outcome? Abdominal muscle training or shoulder girdle strength?

5. several studies from Australia have shown that pain interferes with the activity of trunk muscles, and that positive long term changes can be expected from specific Core exercise compared to general exercise. Studies from Norway have also shown a positive short term and long term effect of actively training the Core. However, therapy studies using subjects with back pain do not necessarily reflect normal populations. Different responses between injured and non-injured has been seen with whole body vibration training, and this may be the case with Core training. Similarly, training effects in well trained populations cannot be expected to be the same as in untrained populations.



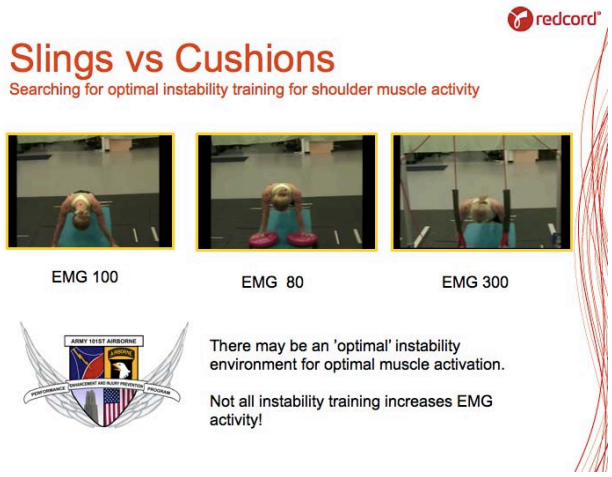


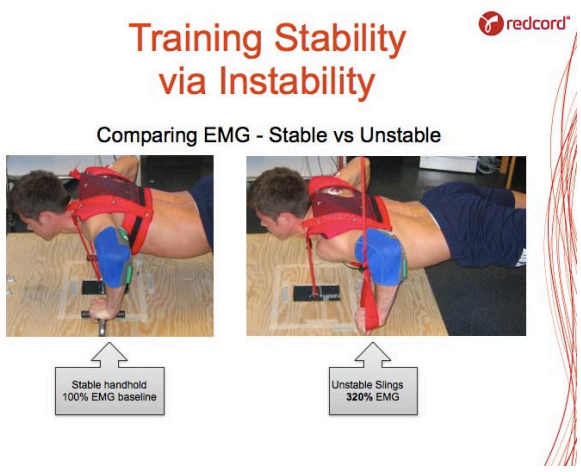
6. specificity is crucial to exercise design, especially in well trained athletic populations. Open-chain and isolated exercise regimes cannot always be expected to transfer to closed-chain performance. Exercises that are performed slowly may not result in increased performance or injury prevention at speed. Exercises performed in inner muscle range (eg. crunch or some Pilates floor exercises) cannot be expected to improve performance in outer range activities (eg. tennis serve). Interestingly, a recent study by Prokopy et al (J. Str.Cond.Res Nov 2008) showed that unstable closed chain exercises were superior to traditional strength training for throwing performance in elite softball players. One may assume that throwing is open chain, however it could be argued that

the trunk or Core initially acts in closed chain during the throwing action. Similar results have been seen with handball throwing, football kicking and balance, and the golf swing.

7. different surfaces or stability challenges appear to elicit different EMG responses in muscles. Pilot studies (presented at Redcord Conference, Oslo, Norway 07/09/2007) by Prof. Scott Lephart at Pittsburgh University showed significant differences in muscle activation for a variety of exercises performed on the floor, on balance cushions and in ropes. This finding was consistent with earlier findings by Prof. Steven Seiler at Kristiansand Idrottshögskolan, Norway. there appears to be an optimal level of instability for maximal muscle activity.

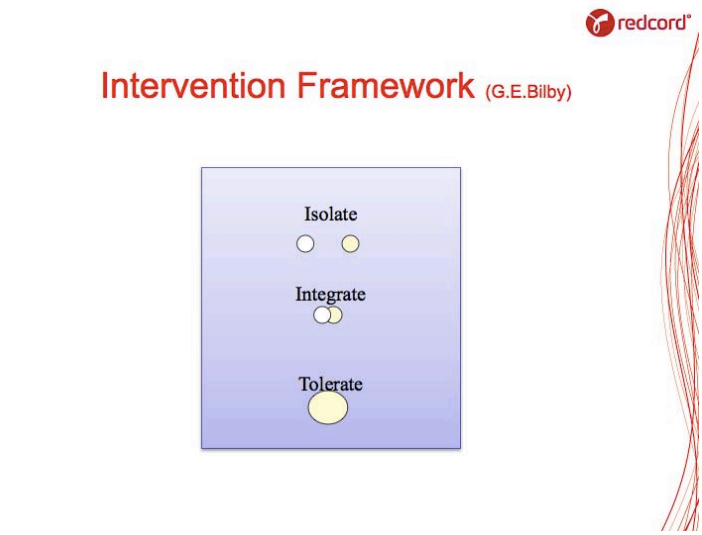
8. according to the adaptation principle, exercises need to be progressed in order to challenge or positively stress the

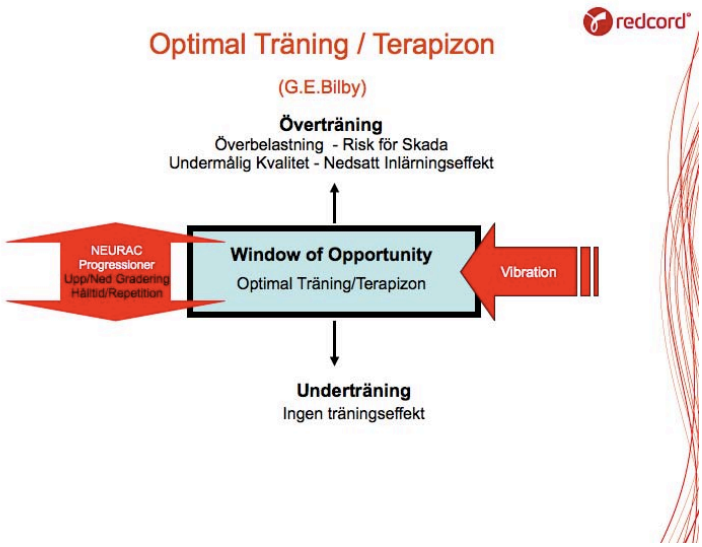


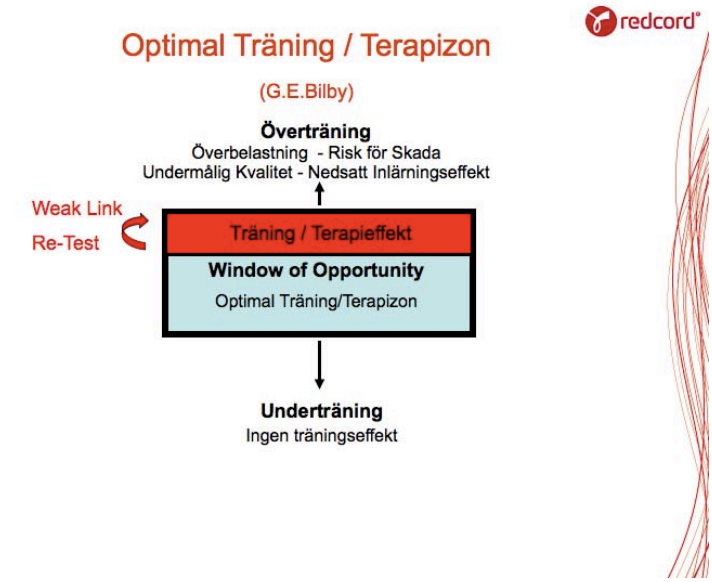


system. The progression may begin training the Core in isolation, however for functional transfer there needs to be some integration of multi-joint stabilizers and prime movers. Weak links (Redcord Neurac), dysfunctions (Janda) or dysfacilitation (Comerford) can be isolated via assessment, retrained or re-activated, and then functionally integrated back into optimal

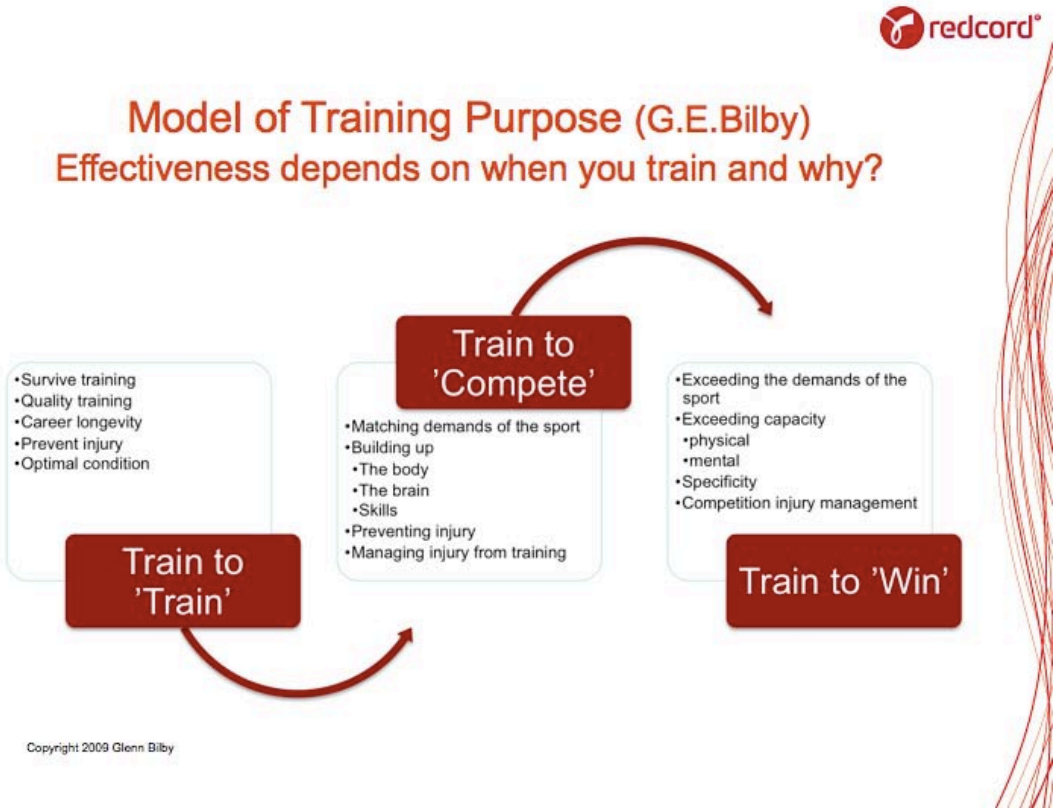
global movement patterns. To benefit from training, training intensity and specificity needs to be in the zone where a training effect can occur. Too little or too much training can have negligible or negative outcomes.







There is sufficient applied research and well established principles of training to support the implementation of Core training in a periodised program. It may be a critical training tool for increasing performance and reducing the risk of injury, but this does not imply it needs to be time consuming. It may simply serve as a building block to successful execution of sport specific training. Core training is certainly necessary during preseason and may be a low impact and fine tuning maintenance tool during the season. It is reasonable to assume that once correct co-ordination, proprioception and muscle balance is achieved, the Core will automatically be active during functional training in fully fit athletes.



A systematic testing protocol that challenges Core strength and stability/robustness is necessary to create individual and team baselines, and to screen for players at risk. A common finding amongst footballers is weakness in outer range trunk control with or without lumbopelvic rotation. This is a common movement in football, however most training activities are performed in inner range and without lumbopelvic rotation.

Once the training professional has evaluated the needs of the athlete and the phase in the training cycle. a deliberate exercise prescription process should be undertaken. In elite sport, it is not satisfactory to waste the athletes time and energy on non-productive exercises.

One of the main questions in the Core exercise debate concerns the extent to which Core exercises and Functional exercises should be unstable. The following slides give a summary of the current attitude to this question, and some training recommendations based on current literature.

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Stable or Unstable Training?

What is the goal?

Motor Control

- Unstable squat versus stable squat causes increased soleus, abdom, upper ES, lower ES activity
- Body weight trunk exercises on ball vs stable causes increased trunk muscle activity
- Proprioception and balance can be achieved via unstable training
- Unilateral lifting (ie. Placing the resistance outside of the base of support) on a ball or bench causes greater trunk muscle activity
- Balance can improve from unstable training.
- Unstable training (+ plyometrics) can reduce the risk of ACL injury

Strength and Power

- ErSp muscle activation can be higher with stable heavy lifting 80% 1RM than Superman and Side Plank on ball
- Squat/Deadlift shows similar activation to Ball exercises in Oblique muscles.
- Strength endurance can be achieved through unstable exercises with moderate loads, but absolute strength and power are best achieved via stable exercises.
- Lifts performed on ball reduce prime mover activity (up to 70%) and increase trunk muscle activity
- Unstable ball training does not improve sprint performance or swimming.
- Hockey skating speed performance is not related to wobble board performance.

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Stable or Unstable Training?

What is the goal?

Injury Prevention

- Train unstable
- Combine with plyometrics / timing
- Combine with stable higher load lifting
- Be as specific as possible

Performance

- Build on an off-season base of stability and balance training
- Foundation of core endurance can facilitate heavy training
- Convert to heavy and unilateral free weight lifting on stable or slightly unstable surfaces
- Introduce perturbations (safely)
- Add rotations and ballistic movements
- Be specific
  - Muscle length
  - Range of motion
  - Speed
  - Contraction type

There are many exercises that fall into the family of Core training, and most of them have their own characteristics as far as forces acting on the body and biomechanics. It is the responsibility of the competent therapist and trainer to understand which exercises suit which functional demands at different phases of a periodised program or rehabilitation schedule.

Every attempt should be made to transfer gains made in isolated Core training to integrated global movements, to postures that offer mechanical advantage, and under circumstances that mimic the speed, timing, sequencing and metabolic demands of actual functional activities. It needs to be recognized that neurological, morphological and metabolic changes take place at different phases, and this should be planned for.

Core training can be methodical and systematic if the principles of exercise prescription are followed, and the tendency to follow mindless fads or be trapped in tradition are resisted.