Myth of core stability

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“If you give a man a hammer he sees nails everywhere”

Mark Twain
In the beginning

Hodges et al. 2000

TA onset

Deltoid onset

Shoulder
Lumbar-pelvic flexion
Lumbar flexion
Hip flex/ext
Lumbar-pelvic lateral flex/ext
Hip ab/adduction
Pelvic rotation
Thoracic rotation

Abdominal pressure
Deltoid
Transversus abdominis
Obliquus int abdominis
Obliquus ext abdominis
Rectus abdominis
Erector spinae

100 ms
Hodges PW, Richardson CA. Altered trunk muscle recruitment in people with low back pain with upper limb movement at different speeds. Arch Phys Med Rehabil. 1999 Sep;80(9):1005-12
Fact vs. Faith

20 ms (one fiftieth of a second)!

- Protect against LBP
- Protect against sports injuries
- Alleviate back pain
- Protect against lower limb injuries
- Stability of scapula
- Protect shoulder
  - Improve shoulder function
  - Improve arm performance
- Stability of cervical spine
- Pelvic stability
- Genitourinary improvements
- Applied elsewhere
- Stability principles
  - Improves posture
  - Improves sports performance
  - Pregnancy pain
  - Reduce chronic neck pain
  - Improve neck function
Topics explored

Passive control of trunk

Motor control of trunk and CS

Motor control in injury

CS exercise and training and motor learning principles

CS in relation to aetiology of LBP
Passive stability
Width of the neutral zone related to joint stability

“These conclusions were drawn from cadaver experiments and mathematical models on which an extensive amount of damage had to be inflicted to the joint before an unstable response was obtained.”

“So far, the neutral zone argument has remained academic.”

Active stability
Active control is dependent on normal motor control
Key issues in motor control

Movement is organised around goals

Motor programmes are recruitment sequences not muscle specific

Muscle recruitment is task specific not muscle specific

Total system organisation – no single muscle activation
Goal movement

Integration

Goal
Task specific not muscle specific

The brain does not know muscles, but only movements..*

[...and its goal]**

*J. Hughlings Jackson 1889, after Charles Edward Beevor (1854-1908)
**my small contribution..
Generalised motor programme

Task specific recruitment: think control not anatomy

Anatomical function

Different recruitment

Same muscle many tasks
Motor control: whole body organisation
Are there specific prime movers and stabilizers?

Lederman E. 2005 Science and practice of manual therapy.
Lederman E. 2005 Science and practice of manual therapy. Elsevier
"No man ever steps in the same river twice"
Heraclitus of Ephesus 475 BCE

No hierarchy in recruitment

Active and silent muscles are equally important!

The many tasks of TA? (with all the other muscles)

Spinal stabilisation / steadiness
Trunk movement
Respiration
Vocalisation
Support of abdominal contents
Part of inguinal valve
Sex..
Task dependent recruitment


Task dependent muscle recruitment: welcome to complexity

No single muscle dominated in the enhancement of spine stability.

Their individual roles continuously change across tasks.

To train for stability, enhance patterns that incorporate many muscles rather than targeting just a few

Global and core subsets

No closed / isolated muscle systems / chains in the body...
Whole body organisation in injury / pain: not just TA

**Multifidus**  
(Carpenter & Nelson, 1999),  
**Psoas**  
(Barker et al., 2004),  
**Diaphragm**  
(Hodges et al., 2003),  
**Pelvic floor muscles**  
(Pool-Goudzwaard et al., 2005),  
**Gluteals**  
(Leinonen et al., 2000)

If a muscle is not involved it is still part of the protection schema / strategy!
Integrate in order to coordinate

Muscle groups / chains do not exist as control subsets

Muscle-by-muscle rehabilitation is not physiological
Is specific activation of core muscles possible?
Conscious selectivity of core muscles

Idealised anatomy vs. reality
“Core muscles” – neurologically co-activated

Visceral & diaphragmatic consequences

Newton’s 3\textsuperscript{rd} law – for every action there is an equal and opposite reaction!

TA not easy to isolate!

Extensive synergistic action
Conscious selectivity of core muscles

No evidence that single muscle activation is possible (or beneficial)
Co-contraction & stability
Components of motor control

Skills

Composite abilities
- Coordination
- Balance
- Transition
- Time
- Motor relaxation

Synergetic abilities
- Co-contraction & reciprocal activation

Parametric abilities
- Force
- Velocity
- Range (length)
- Endurance

Lederman E. 2010 Neuromuscular rehabilitation in manual and physical therapy, Elsevier
Co-contraction is task specific: no universal co-contraction pattern

Co-contraction

Reciprocal activation

Optimum movement efficiency and effectiveness
Co-contraction is useful to a point...

Increase co-contraction

Increase stability

Increase in spinal compression
Increase stiffness / ROM
Increase energy expenditure
A natural muscular activation pattern is ideal for efficient spine stability.

Consciously activate abs at 10%, 20%, 30% or 100% MVC
Or
Naturally chosen manner

A natural muscular activation pattern is ideal for efficient spine stability.

Conscious control of abs decrease stability and safety margin

What is all the fuss about??

Co-contraction in standing is less than 1% MVC
3% MVC when a 32 Kg weight is added to the torso.
With a back injury it raise these values by only 2.5% MVC for the unloaded and loaded models

During bending and lifting a weight of 15 kg co-contraction increases by only 1.5% MVC

Cholewicki et al., 1997, van Dieen et al., 2003
The obsessive focus on stability

Cocontraction and ‘active stability’ is only another motor control pattern (depends on motor control and not on specific muscles)

Core stability – too much focus on stability, not enough on movement (reciprocal strategies and coordination)
“Exercise X” vs. core co-contraction exercise

First attempt
No rehearsal or training
No internal focus on the core muscles
0 costs
Neuromuscular re-organisation in injury
The standard injury response: all motor components affected

Skills

Composite abilities
- Coordination, Balance, Transition
- time, motor relaxation

Synergetic abilities
- Co-contraction & reciprocal activation

Parametric abilities
- Force, velocity, range (length), endurance
The standard injury response: all motor components affected

<table>
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<tr>
<th>Primary motor abilities</th>
<th>Synergistic</th>
<th>Composite</th>
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<tr>
<td>Force</td>
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<td>Transition rate</td>
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<td>Relaxation</td>
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**LBP**
- Force losses in trunk muscles in acute and CLBP patients (Shirado 95, Hides 94&96, Ng, Airaksinen)
- Loss of flexion relaxation in the spinal muscles during flexion in patients with CLBP. Extensors activation prevents full forward bending (Shirado 95b)
- Individuals with high pain-related fear had smaller excursions of the lumbar spine for reaches to all targets at 3 and 6 weeks, but not at 12 weeks following pain onset (Thomas 08)
- Smaller stride length (Lamoth 08)
- Reduced velocity of trunk movement during induced back pain (Zedka)
- Individuals with high pain-related fear had smaller peak velocities and accelerations of the lumbar spine and hip joints, even after resolution of back pain (Thomas 08)
- Walking velocity significantly lower in LBP patients (Lamoth 06a&b 08)
- Increased fatigability trunk muscles in patient with CLBP (Suter, Shirado, Roy)
- Impaired postural control of the lumbar spine is associated with delayed trunk / abdominal muscles response times in CLBP patients (Radebold, Hodges 96, 98,99,03 O'Sullivan, MacDonald, Thomas 07a&b)
- Increase in trunk co-contraction in CLBP patients (Cholewicki, Van Dieen)
- Increase cocontraction in trunk during walking and additional cognitive demands (Lamoth 08)
- Lumbar spine-hip joint coordination altered in back pain subjects (Shum)
- Dis-coordination in pelvis-thorax coordination in LBP (Lamoth 06a&b)
- Changes in postural control in CLBP (Popa, Leinonen)
- Impaired postural control of the lumbar spine associated with delayed muscle response times in CLBP patients (Radebold)
- Changes in postural control unrelated to pain in CLBP (della Volpe)
- Post spinal surgery postural control changes both in pain and pain-free subjects. However, more evident in the symptomatic subjects. (Bouche)
- Hip strategy for balance control in quiet standing is reduced in CLBP (Mok)
- Experimental muscle pain changes feedforward postural responses of the trunk muscles (Hodges 03)

Compared to healthy controls, persons with LBP exhibited a reduced ability to adapt trunk-pelvis coordination and ES muscle activity to sudden changes in walking velocity (Lamoth 06a&b)
Slower reaction time in LBP patients.
Demonstrated recovery of reaction time with training (Luoto)

No available data

Lederman E. 2010 Neuromuscular rehabilitation in manual and physical therapy, Elsevier
Conclusion

Injury, pain and fear result in protective motor reorganisation

Many components of control are affected as a consequence of pain and injury, including co-contraction

There is no proof that any one component is the cause of injury

There is no proof that stability failure is a cause of LBP
The timing issue
The great leap of faith

1. Timing differences in LBP

2. Do core stability exercise improve timing?
   (done much later, 1 very poor quality study)

3. Do CS exercise improve timing in LBP?
   (done much later, 1 very poor quality study)

4. Is improvement in timing correlated with improvement in LBP

5. Core stability exercise may improve LBP, but is this improvement associated with improved timing? No study assessed timing or ability to stabilise
One prospective study in athletes

The odds of sustaining LBI increase by 3% with each millisecond of abdominal muscle shut-off latency.

Athletes with LBI had an average of 14 milliseconds latency

No control from another reference part of the body

Cholewicki J. Delayed trunk muscle reflex responses increase the risk of low back injuries. Spine. 2005 Dec 1;30(23):2614-20
One study in athletes

In my books, general "motor clumsinesses" is precisely the issue of stability

Cholewicki J in email correspondence

It's all about reaction times…

In healthy individuals reaction times are unchangeable…

Cholewicki J Delayed trunk muscle reflex responses increase the risk of low back injuries. Spine. 2005 Dec 1;30(23):2614-20
Can CS exercise change TA timing?

**Study 1**
After 1 session of training:
No change in onset times of trunk muscles during arm movements or walking ……

**Study 2**
After 4 weeks of training:
Transfer of improvement into the testing procedure
No change in onset times during walking
No relationship between improvement in timing and LBP

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Control linked to biomechanics?

“delay of TrA is likely to be longer than that for DM due to its long elastic anterior fascias. Earlier activity of TrA may compensate for this delay”.

Pain evasion strategy?

Perhaps there is a protective advantage in delaying TA?

“Likely to reflect development and adoption of an alternate postural adjustment strategy, which may serve to limit the amplitude and velocity of trunk excursion”


Can CS exercise normalise timing?

Not demonstrated
Are strong abs trunk muscles essential for:
Stability?
Protect the back?
Reduce LBP?
Are strong abs essential for stability?

TA is absent or fused to the internal oblique muscle as a normal variation

Gray’s Anatomy (36th edition 1980, page 555)
Trunk muscles activity during functional tasks

In standing, ES, psoas and QL are virtually silent!

In some subjects there is no detectable EMG activity in these muscles

(Andersson et al., 1996)

During walking rectus abdominis has an average activity of 2% MVC and external oblique 5% MVC

(White & McNair, 2002).
Reserves

Dramatic loss before functionally is affected
Trunk muscles physical capacity and risk of LBP

Physical capacity: isokinetic lifting strength, static muscle endurance and spinal ROM + High or low physical work exposure = LBP ?

Imbalance between low physical capacity and high work exposure yield same risks for LBP as high balance or low balance

N=1789 / over 3 years

Strength issue: loss of muscle strength / mass – does it matter?

No relationship between trunk muscle endurance and the risk of LBP.

Inconclusive evidence for trunk muscle strength, and the risk of low back pain.

Prospective study of healthy subjects:
No risk developing LBP from low activity or fitness levels (n=3760)

Abdominal muscles in preg
Loss of stability and LBP

Postpartum, Rectus abdominus takes about 4 weeks to re-shorten, and 8 weeks for pelvic stability to normalize (Gilleard & Brown, 1996)

Out of 869 pregnant women, 635 were excluded because of their spontaneous unaided recovery within a week of delivery (Bastiaenen et al., 2006)
Is LBP in pregnancy due to force / stability loss?

No correlation between the sit-up performance and backache in pregnancy.
16.6% of pregnant women could not perform a single sit-up.

Potentially unsafe?

In patient with pelvic girdle pain increased intra-abdominal pressure could exert potentially damaging forces on various pelvic ligaments.

Study recommends teaching the patients to reduce their intra-abdominal pressure, i.e. no CS.

Mens et al., 2006
Are strong abs essential for stability?

Weight gains and obesity are only weakly associated with LBP

(Leboeuf-Yde, 2000)
Are abs essential for stability?

Results in weakness of abdominal muscles. No effect on back pain or impairment to the patient’s functional / movement activities, measured up to several years after the operation (Mizgala et al., 1994; Simon et al., 2004).
“Core” exercise and overloading: is it enough?

Sung PS 2003 Multifidi muscles median frequency before and after spinal stabilization exercises. Arch Phys Med Rehabil 84(9):1313-8
Underloading...not sufficient for muscle hypertrophy


LRA – lower rectus abd.
URA – upper rectus abd.
EO – external oblique
ES – Erector spinae
MT – multifidus
Endurance and CLBP

In a study of fatigue in CLBP, four weeks of stabilisation exercise failed to show any significant improvement in muscle endurance.

Sung PS 2003 Multifidi muscles median frequency before and after spinal stabilization exercises. Arch Phys Med Rehabil 84(9):1313-8
Conclusion: strength, stability and LBP

Imbalances between trunk muscles are normal variations

Large imbalances can be tolerated without loss of function or pain

No known relationship between strength, endurance and LBP

No study has shown that strengthening core muscle will re-normalise timing!
Conflicts with specificity in training
Generalisation & specificity

Generalisation – ability to apply what has been learned in one context to other contexts

Specificity – unique adaptation to a particular task
Specificity principle

You learn what you’ve practiced
Specificity of training

Lederman E. 2005 Science and practice of manual therapy. Elsevier
Transfer in training

Transfer – how the performance of a task is influenced by the conditions of the practice
Potential contents of transfer

Movement programme elements – e.g. intermuscular sequences

Task parameter – force, velocity, range or endurance

Motor abilities – e.g. balance or coordination

Fitness/conditioning component
How transferable is rehabilitation?

Highly transferable

Inter-task & Dissimilar

Lumbro-pelvic tilts practiced on the floor
Core tensing or bracing
Extension exercise on the floor

Walking

Core tensing or bracing in walking (this may seem surprising. As long as the person is walking they are practicing walking. The dissimilar movement is redundant as far as motor learning)

Walk

Reaching with the arm

Weight training for biceps
PNF cross patterns of arm movement

Practicing elbow flexion

Complex PNF arm movements

Reaching with the arm

Intra-task & Similar

Laying on the floor moving both legs in a walking-like pattern

Intra-task & Dissimilar

Core tensing or bracing in walking (this may seem surprising. As long as the person is walking they are practicing walking. The dissimilar movement is redundant as far as motor learning)

Intra-task & Similar

Laying on the floor moving both legs in a walking-like pattern

Least transferable

Reaching with the arm

Weight training for biceps
PNF cross patterns of arm movement

Practicing elbow flexion

Complex PNF arm movements

Reaching with the arm

For example:
“Deep multifidus and TrA do not maintain tonic co-contraction.

“Training co-contraction of DM and TrA unlikely to restore typical activation patterns”.

Is it similar enough?
A functional approach

Functional movement - the unique movement repertoire of an individual.

Functional rehabilitation - the process of helping a person recover their movement capacity by using their own movement repertoire (whenever possible).

Extra-functional – a movement pattern outside the individual’s movement repertoire

Lederman E. 2010 Neuromuscular Rehabilitation in manual and physical therapies. Elsevier
Context principle

Within their environment

In context of what a person does

In context of what a spine does

Lumbar spine
Dorsal spine
Cervical spine

Lederman E. 2010 Neuromuscular rehabilitation in manual and physical therapy, Elsevier
Conflicts with focus of attention and motor learning and performance
Internal-external focus (goals)

External focus – on target / goal

Internal focus – on body

“Extreme” internal focus – on specific muscle / joint

McNevin et al., 2000; McNevin et al., 2003; Wulf et al., 2002; Wulf et al., 2003
Internal – external focus

Group 1 - Focus on biceps

Group 2 - Focus on lifting the weight

Lower EMG activity in external focus…


Golfers should not be thinkers
Economy of movement

“to improve locomotion (and motion), mechanical work should be limited to just the indispensable type and the muscle efficiency be kept close to its maximum. Thus it is important to avoid: .... using co-contraction (or useless isometric force)”


“At higher levels of competition, it is likely that 'natural selection' tends to eliminate athletes who failed to either inherit or develop characteristics which favour economy”

Core and sports performance

Few studies have observed any performance enhancement in sporting activities despite observing improvements in core stability and core strength following a core training programme.
Is there a relationship between core strength and performance?

Core stability and functional movement screening are not strong predictors of performance.

Increases in core strength will not contribute significantly to strength and power and should not be the focus of strength and conditioning.


Core stability in prevention of injury and therapeutic value
Prevent injury?

Most sports injuries occur in less than ten milliseconds

Ankle sprains in about 17ms

Shortest spinal monosynaptic reflex responses >20 milliseconds

Apply maximum torque to the leg, just short of eliciting pain

Muscles acted too slowly to stiffen and protect / prevent the knee from injury as in typical sports situations.


Prevent injury?


Is sport activity a risk factor for LBP?

Recreational sports or exercises not associated with LBP

No studies / evidence for professional sports as risk for LBP

Is non-contact LB injury due to lack of trunk control?

**NO evidence**

One study using poor methodology (Cholewicki et al 2005).**

**See discussion: Lederman E 2010 The fall of the postural-structural-biomechanical model in manual and physical therapies: Exemplified by lower back pain**

Free download: http://www.cpdo.net/jour/jour1.html
Is core strength and endurance associated with lower limb injury?

**NO**

Does CS exercise reduce LB injury in sports?

NO

### CS training and LBP

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<tr>
<th>Description</th>
<th>CS compared to:</th>
<th>Result</th>
<th>Note</th>
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<tbody>
<tr>
<td>O’Sullivan et al., 1997</td>
<td>CLBP (spondylolysis or spondylolisthesis)</td>
<td>General practitioner care</td>
<td>CS better</td>
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<tr>
<td>Hides et al., 2001</td>
<td>Recurrence after first episode LBP</td>
<td>General practitioner care + medication</td>
<td>CS better</td>
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<tr>
<td>Niemisto, et al., 2005</td>
<td>LBP</td>
<td>CS + manip + physician care compared to just physician care</td>
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<tr>
<td>Goldby et al., 2006</td>
<td>CLBP</td>
<td>Control and MT</td>
<td>CS first MT second</td>
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<td>Stuge et al., 2004</td>
<td>LBP in pregnancy</td>
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<td>Bastiaenen et al., 2006</td>
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<td>Cognitive behavioural therapy (CBT)</td>
<td>CBT better</td>
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<td>Critchley DJ et al 2007</td>
<td>Chronic LBP</td>
<td>General physiotherapy Stabilisation exercise CBT</td>
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<td>Nilsson-Wikmar et al., 2005</td>
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<td>CLBP</td>
<td>General exercise</td>
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<tr>
<td>Rasmussen-Barr et al., 2003;</td>
<td>CLBP</td>
<td>General exercise</td>
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<tr>
<td>Cairnes et al 2006</td>
<td>Recurrent LBP</td>
<td>Exercise + MT</td>
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<td>Stevens VK 2007 (unpublished)</td>
<td>CLBP</td>
<td>specific stabilization therapy versus general trunk reconditioning</td>
<td>Same</td>
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</table>
Can CS exercise reduce back pain?

Yes!

but..

Not more effective than manual therapy or other forms of exercise


No better to a daily walking program.....

People of the world relax (your trunk)

Tensing or strengthening your trunk muscles:

- Will not prevent back or other injuries
- Not better than exercise or walking for LBP
- Will not improve your sports performance
- Don’t pathologise the patient with core stability ideals
Lecture notes and references see: **WWW.CPDO.NET**

For working with motor control see: **Neuromuscular Re-abilitation**