COREWERKS

CHANGE YOUR CHAIR
CHANGE YOUR LIFE

The CoreWerks Approach to Treating Low Back Pain, Enhancing Spinal Stability and Increasing Attentiveness

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Executive Summary

The CoreWerks Therapeutic Dynamic Technology evolved from the founder's efforts to prevent spine fusion surgery for his son who is afflicted with CP induced neuromuscular scoliosis.



It was aimed at creating an environment that would enable the boy to find his balanced posture and to progressively learn how to balance.

Observations made during therapeutic horseback riding (Hippotherapy), the boy tried to immediately balance and sit erect on his own when on the horse, lead to the current design which transfers the benefits of Hippotherapy into a seating system.

What are the benefits of Hippotherapy?

Hippotherapy stimulates the spinal and vestibular proprioceptors and gets them into a perfect state of alignment, leading to proper sensory motor integration, a key condition for enabling information flow into the cortex and memory formation. A benefit which has been demonstrated with children afflicted with Autism, ADD and ADHD and Cerebral Palsy

How does Hippotherapy create perfect alignment of spinal and vestibular proprioceptive input?

The horse's canter creates a small oscillating side to side tilting movement with limited tilt amplitude around the midline of the horse's back, exciting the spinal and vestibular to provide afferent sensory input to the Central Nervous system. This particular type of tilting movement only involves the core muscles and not the outer global muscles, because of the isolated stimulation of the spinal proprioceptors and therefore causes a well balanced posture.

CoreWerks has transferred the characteristics of the movement associated with Hippotherapy into its seating system design. The system immediately engages the spinal and vestibular proprioceptors and afferent sensory information leads to the recall and application of the proper neuromuscular control patterns resulting in the proper activation of the core muscles for a balanced posture. The effect is immediate.

The CoreWerks seating technology places the pivot for the movement as close as possible to the user's pelvis and is designed to be unstable around the midpoint, for activation of spinal and vestibular proprioception, while experiencing an increase in tilt resistance with increasing tilt angle, providing for the edge to the movement that creates the feeling of safety, to avoid triggering the limbic system into fight / flight mode.

The CoreWerks technology has demonstrated benefits in the treatment of non-specific low back pain, recently traced to neuromuscular control problems because of lack of sensory input), Cerebral Palsy, Autism and ADD and ADHD as well as MS.

Common to all ailments is that insufficient and poorly alignment of afferent sensory input leads to sensory processing issues in the central nervous system.

The CoreWerks system based on its unique design brings vestibular and spinal proprioceptive inputs into alignment and enables proper sensory processing allowing for increased attentiveness and memory formation as well as improved core health and greater sitting comfort,

In summary our bodies were designed to move to stay healthy and not to sit in front of a computer, and CoreWerks delivers the right kind of movement.

Posture and Core Stability

It has become an acknowledged fact that the stability of the spine and therefore its health depend on a healthy core. The core provides stability and support to the spine and the torso. A weak core will lead to injury of the spine, especially the intervertebral discs.

What constitutes the core?

Core

The skeleton of the torso, looks like a tree, with the Thoracic part being the crown of the tree, the lumbar spine being the trunk and the sacrum being the root attached the pelvis via the sacroiliac joint.

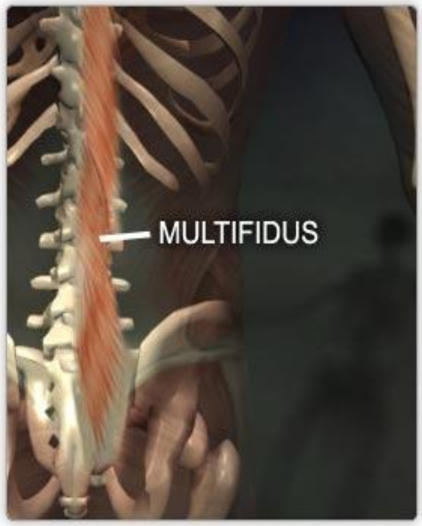
The spine itself is like a chain and its only stable condition is when hung from the top but not standing on the sacrum.

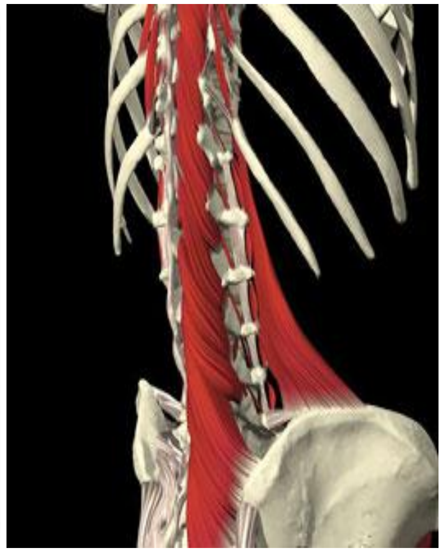
To have the spine and torso standing up straight, muscles are needed to provide stability to it.

These muscles are:

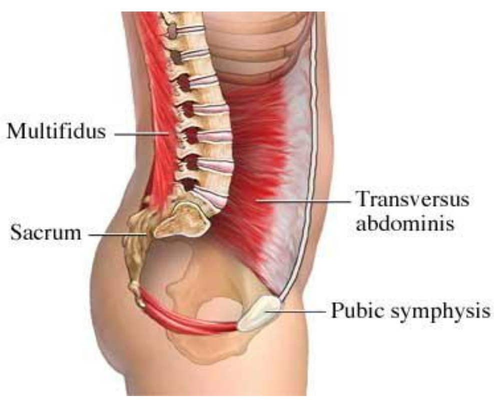
Stabilizing muscles

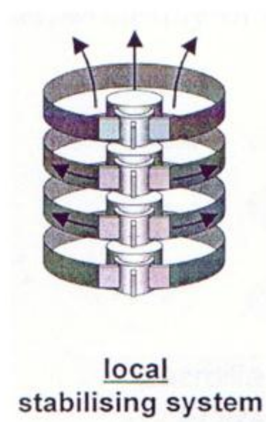
Lumbar Multifidus: interweaving the vertebrae like a robe, stiffening the spine and providing intersegmental movement and stabilization.



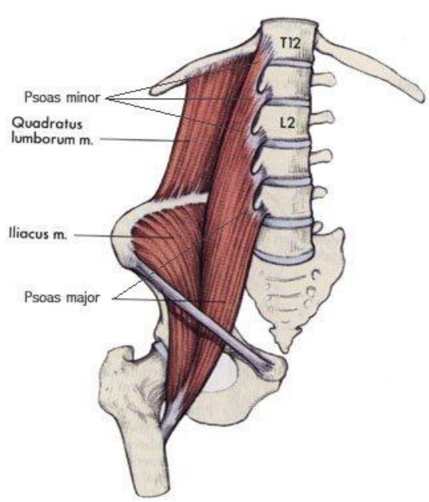


Transverse abdominis:





Wrapping around the midsection of the trunk, connecting the spine with rectus abdominis, and the ribs to the Ilium, it acts like a cylinder or barrel holding up the ribcage.

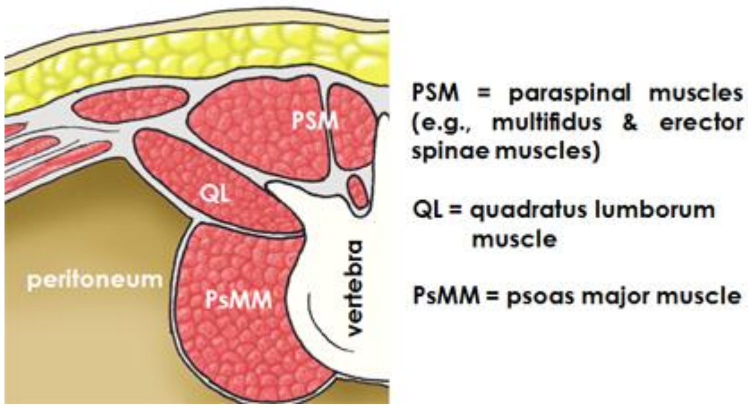


Quadratus Lumborum and Psoas Major:

Quadratus Lumborum:
It connects the iliac crest with the spine and 1st rib, connecting the trunk of the tree with the ground

Psoas Major:

It connects the spine with the femur. Psoas Major and Quadratus Lumborum create a tent like structure tied to the foundation, supporting the spine.



Paraspinals:

The paraspinal muscles are the muscles that run next to, and roughly parallel with, the spine. They consist of many small muscles that are attached to the vertebrae and control the motion of the individual bones, as well as assist with the larger motions of the whole trunk, or core, area. Together with other muscles, they help support the spine and keep it in proper alignment. They also limit the range of motion of the spine, which helps to prevent injuries to the disks and spinal cord caused by overextension.

In human anatomy, nearly all skeletal muscles work in pairs. While one muscle is contracting, or getting shorter, another muscle must get longer to allow movement. When you bend forward, your paraspinal muscles are lengthening; when you stand up again, they are contracting to pull you back to a standing position. Paraspinal muscles on the left and right side of your body work together in the same way when you are bending sideways. When you are not bending, the paraspinal muscles keep your spinal column in vertical alignment while you are sitting or standing.

Paraspinal muscles are thought to play an important role in preventing serious back injuries, such as a herniated disk. When you experience a back spasm, it is often a paraspinal muscle tightening up, which is a warning signal that your back is either bearing more weight than it should, or bending and twisting improperly. Paraspinal muscle spasms are extremely painful; the pain normally stops a person from doing whatever activity caused the pain, before a more serious injury to the disks or spinal cord can occur. In this way, a back spasm can prevent a serious injury, as well as protect an existing injury while it is healing. A paraspinal muscle strain, while very painful, will heal much more quickly than a disk injury.

The paraspinal muscles do not work alone; they are part of an interconnected network of muscles that wrap around the chest, abdomen, and pelvis. All of these muscles work together to protect the spine and allow movement within a safe range.

Included in the paraspinal muscles are the deep laying intersegmental muscles;

These muscles act across a single joint in parallel with a vastly larger and longer muscle, the multifidus, and are considered as functioning as kinesiological monitors generating important proprioceptive feedback to the central nervous system

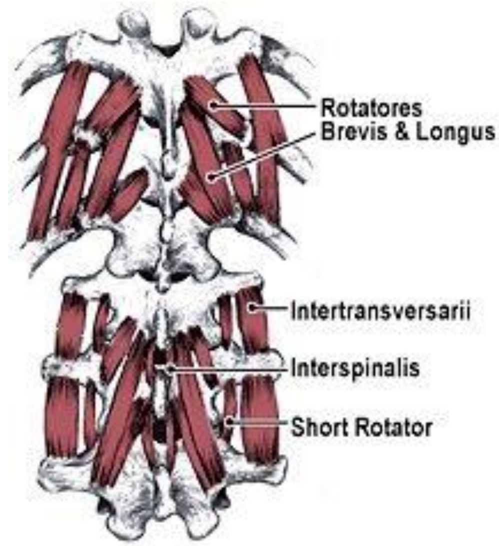
Core stability

For the spine to be dynamically stable, the neuromuscular control system needs sensory input from the proprioceptors (sensors that detect our location in space) that sense the movement of the individual joints as well as a sequence of joints as well as the spine as a whole.

The first role that spinal proprioceptors play is to provide the CNS with information about paraspinal tissue distortion, length, and changes in length, providing us with our perception of the position and movement of the spine. The second major function of the spinal proprioceptors is in the initiation of spinal reflexes that serve to provide stability to the spine and protect the spinal joints and paraspinal tissues.

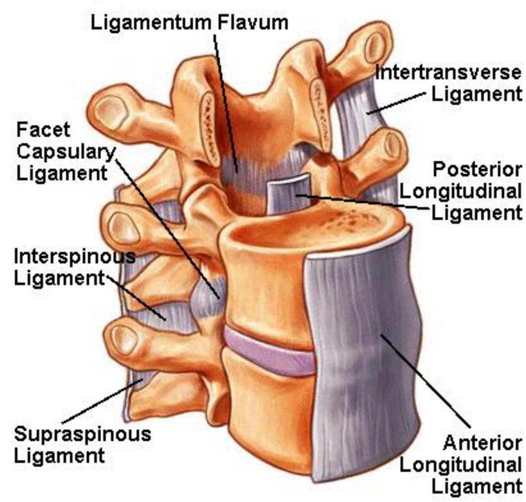
These sensors include:

- The deep laying intersegmental muscles, including intervertebral, i.e., intertransversarii, interspinalis and rotatores as well as the multifidus muscles.
- nerve endings in the disc,
- spinal ligaments
- zygapophyseal joints of the spine



Of particular importance is the neuromuscular control of spinal motion and spinal segment stability that occurs not only through activation of movement synergies by higher brain centers, but also through a complex reflex activation of local musculature initiated by various proprioceptive spinal structures. Spinal proprioceptors serve two functions:

- Position sense and kinesthesia
- Neuromuscular control, where afferent input initiates reflex activation of local musculature to guide movement and produce spinal stability.



Neuromuscular control for spinal stability

Adequate neuromuscular control is essential to dynamically stabilize joints.

Neuromuscular control is defined as the efferent (from brain to muscle) response to afferent (from proprioceptor to brain) sensory information provided to the Central Nervous System (CNS).

The passive spine (consisting of spinal motion segment including intervertebral disc, spinal ligaments, joint capsules, and passive muscle) is inherently unstable.

Well coordinated muscle support provides the spine with the stability required for optimum function.

Muscular support is provided by the neuromuscular control system, which regulates the degree of muscle tone around the joint so the there is appropriate muscle stiffness to dynamically restrain the joint and protect from injury. Research on neuromuscular joint control of the spine has only recently begun to be studied.

Two mechanisms of neuromuscular control coordinate the efferent responses to afferent information.

Feedforward Neuromuscular Control:

Feedforward neuromuscular control involves the planning of movements based on sensory information derived from past information. (These are the movement patterns that we have acquired through training and learning in childhood.)

What happens here is that muscle activation patterns are pre-programmed in anticipation of specific movements and joint loads.

The advantage of feed forward neuromuscular control is that centrally generated motor commands originating from higher brain centers allow the muscles around the joint to be pre- tensioned so the joint is proactively protected from the anticipated load stress placed on the joint.

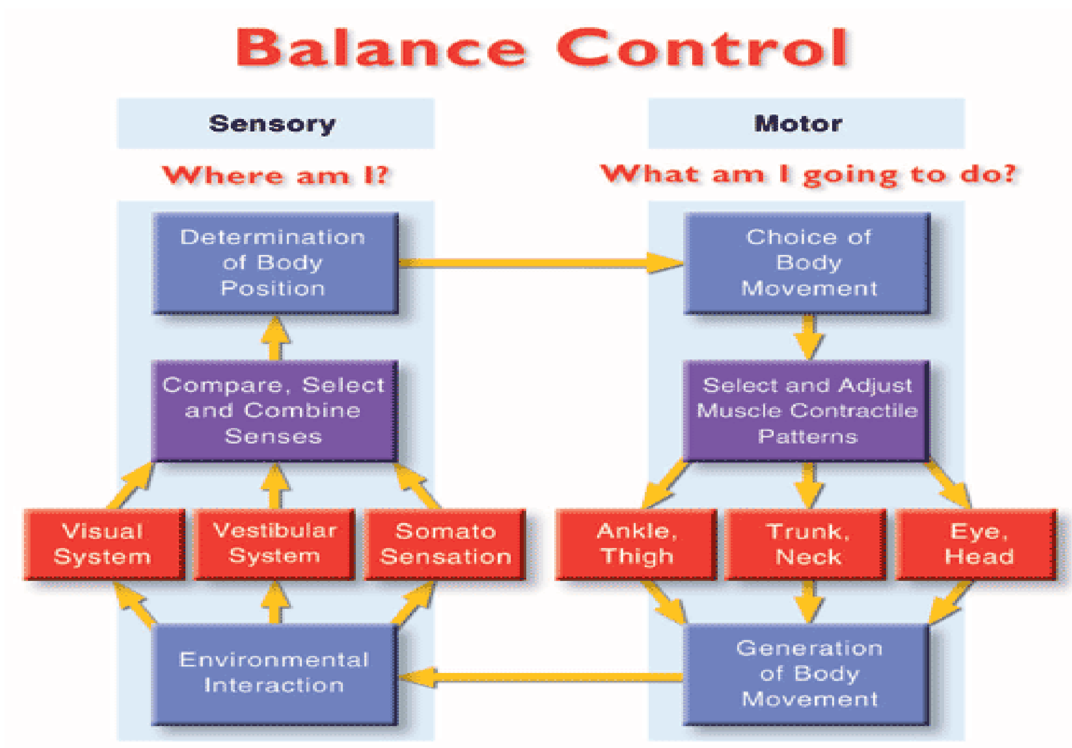
The centrally generated motor commands are constructed and updated on the basis of proprioceptive and kinesthetic information previously provided by the local the joint tissues.

This method of neuromuscular control is thought to be critical for dynamic joint stability.

Feedback Neuromuscular Control:

Feedback neuromuscular control encompasses the more traditional view of how the CNS processes afferent signals. Efferent responses are constructed on local reflex pathways and are activated on the basis of ongoing afferent input (past experiences) in concert with motor commands initiated from higher levels of the CNS, including motor cortical areas.

Both feedforward and feedback neuromuscular controls are used to dynamically stabilize the spine.



Low Back Pain

Most patients suffering from acute low back pain will usually recover within a 2 -4 week period. However, recurrence of episodes of low back pain may be as high as 60- 80%.

One assumed cause is lumbar spine segmental instability as proposed by Panjabi. (Panjabi, A.A. The stabilizing system of the spine. Part I, Function, dysfunction, adaptation and enhancement. J. Spinal Disorders, 1992; 5 (40 383-389).

He proposed that lumbar instability might be the result of loss of control and excessive movement around the neutral zone of the spinal segment brought about by injury to the spinal tissues, degenerative changes in spinal joints, disease or muscle weakness.

Causes

Injury to low back pain and muscle atrophy due to non-use

As soon as the pain sensors (nociceptors) detect an injury, disc or muscle, of your lower back, the brain based on the information provided by the nociceptors, immediately sends efferent information to and stiffens the muscles around the injured site to protect it and then starts to work on creating a compensatory muscle activation pattern that protects the injured site from further injury and for healing.

"Numerous changes have been identified in the LBP population, including increased activity in the erector spinae muscles during trunk movements, delayed relaxation in response to unloading, and reduced activity during functional movements. …….This study reinforces the evidence for changes in automatic control of the Transverse Abdominis muscle in people with Low Back pain."

*(*Changes in recruitment of the Abdominal Muscles in People with Low Back Pain. Ultrasound measurement of muscle activity. Ferreira, P.H., Ferreira, M.L. Hodges, P.W.: Spine 29, 22, 2560 – 2566, (2004))

The compensatory muscle activation is now going to be used as the standard until the brain gets told through afferent sensory information from the previously injured muscle that it is now OK to use these muscles again.

fMRI studies conducted by Tsao, Galea and Hodges show that individuals with chronic low back pain have different cortical recruitment patterns than healthy individuals.

(Reorganization of the motor cortex is associated with postural control deficits in recurrent low back pain, Tsao, Galea, Hodges, Brain (2008) pg 1 – 11

"…These findings provide … evidence of reorganization of trunk muscle representation at the cortex in individuals with recurrent low back pain, and suggest this reorganization is associated with deficits in postural control."

The relative **permanency of the compensatory muscle activation pattern** is shown by a study conducted by the same group demonstrating that **deep back muscle activity** is **different in people** with a **recurrent unilateral Low Back Pain**, **despite resolution of symptoms**.

"Deep muscle activity is critical for normal spinal control; this is evidence for the importance of recurrence of low back pain after injury."

("Why do some patients keep hurting their back? Evidence of ongoing back muscle dysfunction during remission from recurrent pain." MacDonald et al, Pain 142 (2009) 183 -189)

The above study also shows that the lumbar multifidus, the muscle that interweaves the spine for increased rigidity, starts to immediately atrophy after an injury. It does not recover on its own without external stimulation. Specific stabilization exercises have to be performed to bring the Multifidus back to its original size.

"Despite high fitness levels and often intensive strength training programs, athletes still suffer LBP. The incidence of LBP among Australian cricketers is 8% and as high as 14% among fast bowlers. Previous researchers have found that the multifidus muscle contributes to segmental stability of the lumbopelvic region; …. Multifidus muscle atrophy can exist in highly active, elite athletes with LBP. Specific retraining resulted in an improvement in multifidus muscle CSA and this was concomitant with a decrease in pain."

(Hides, J; Stanton, W; McMahon, S; Sims, K; Richardson, C; Effect of Stabilization Training on Multifidus Muscle Cross-Sectional Area among young elite Cricketers with Low Back Pain. *J Orthop Sports Phys Ther. 2008; 38(3):101-108,*

Other studies show that low back injury causes a change in timing between the activation of the core muscles and the muscles activated for volitional task, the volitional task muscle activation occurs before activation of core muscles occurs, leaving the core exposed to injury through external loads.

What are the consequences of a loss or a reduction in proprioceptive acuity for the spine?

Both studies indicate that the lack of proprioceptive input from the spinal proprioceptors leads to the use of compensatory muscle activation patterns.
The lack of proprioceptive input can arise from:

- Injury
- Lifestyle changes toward a more sedentary one lead to nonuse followed by an atrophy of the core muscles, i.e., the proprioceptors fall "asleep". Comfortable conventional seating leads to less stimulation of and therefore less proprioceptive output from the spinal proprioceptors, resulting in reduced activation of the core muscles. This activation is based on the reflex loop for neuromuscular control mentioned above. Afferent proprioceptive information is required for automatic stabilization of the core.

Question: Why do the deep back muscles not recover to their original functionality?

Based on the learned pain avoidance muscle activation patterns the brain will continue to use the compensatory muscle activation patterns that have protected it from experiencing pain even though the recovery has occurred. There is no self initiated stimulus to go back to the original pattern.

To re-establish the proper muscle activation patterns it will be necessary to selectively activate the deep back muscles, or more specifically the proprioceptors that are responsible for the neuromuscular control and stabilization of the spine. Selectively activating the spinal proprioceptors will reactivate the proper **feedforward** muscle activation pattern and the associated reflex arcs.

*"……**these findings suggest deficits in postural control in a patient population are associated with reorganization of the motor cortex.** In patients with recurrent low back pain, these deficits in postural activity can **be trained by skilled motor training**……. **Skilled motor training induces greater plastic change at the motor cortex than strength training**.*

(Reorganization of the motor cortex is associated with postural deficits in recurrent low back pain.)

Tsao, Galea and Hodges, Brain (2008)

The key to successful reactivation of proper postural strategies is **isolated activation of the core muscles** and **avoidance of co- activation of the global volitional muscles**. Activation of the global muscles is reinforcing the compensatory patterns.

*"Although deficits in the activation of abdominal muscles are present in people with low back pain (LPB), this can be modified with motor training. Training of **deep abdominal muscles in isolation from the other trunk muscle**s, as an initial phase of training, has been **shown to improve the timing of activation of the trained muscles,** and **reduce symptoms and recurrence of low back pain**. ……The results of **this study** suggest that unlike **isolated voluntary training**, co-contraction of the trunk muscles does not **restore the motor control of the deep abdominal muscles** in people with Low Back pain **after a single session of training**."*

(Immediate effects of co-contraction training on motor control of the trunk muscles in people with recurrent low back pain. Hall, L., Tsao, H., MacDonald, D., Coppieters, M., Hodges, P.W.: Journal of Electromyography and Kinesiology 19 (2009), 763 -773)

(Persistence of improvements in postural strategies following motor control training in people with recurrent low back pain. H. Tsao, P.W. Hodges /Journal of Electromyography and Kinesiology, 18 (2008), 559 - 567)

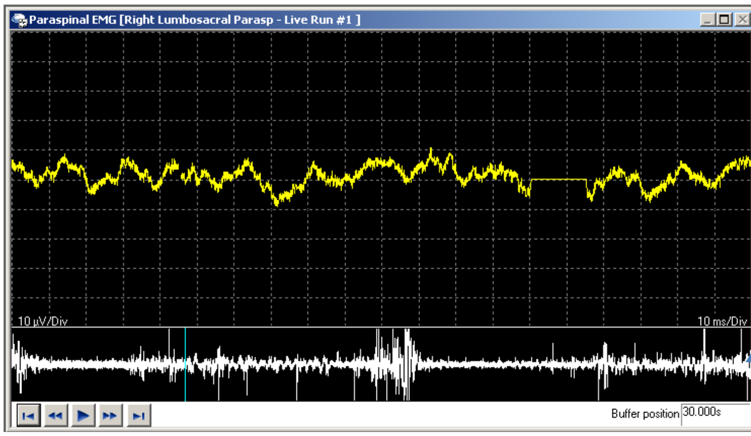
One of the most interesting features of isolated core activation is that the brought about feedforward postural adjustments are immediately available.

"*There is limited evidence that preprogrammed feedforward adjustments, which are modified in people with neurological and musculoskeletal conditions, can be trained and whether this depends on the type of training. … we investigated whether training involving voluntary muscle activation (*in individuals with recurrent low back pain*) can change feedforward mechanisms, and whether this depends on the manner in which the muscle is trained. **Following a single session of training of isolated voluntary activation** of Transverse Abdominis (TrA), onset of TrA ……**was ..to closely resemble the movement strategy of healthy individuals** …The results provide evidence that **training of isolated activation leads to changes in feedforward postural strategies**, and the magnitude of the effect is dependent on the type and quality of motor training.*"

(Immediate changes in feedforward postural adjustments following voluntary motor training, H. Tsao, P.W.Hodges: Exp. Brain Res. (2007) 181:537 - 546)

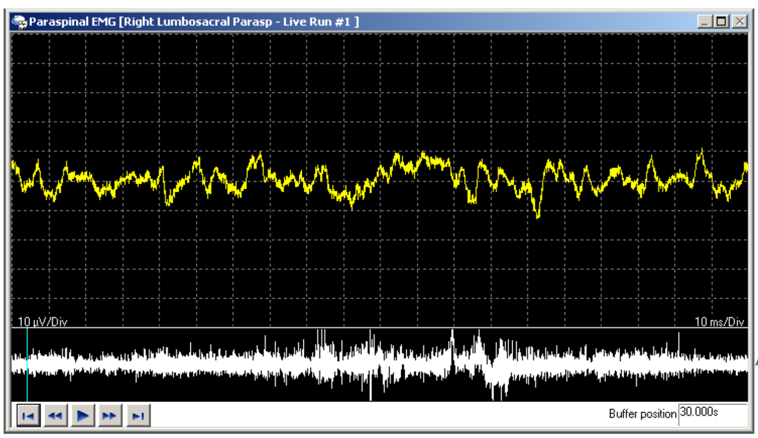
CoreWerks Dynamic Therapeutic technology stimulates core activation while sitting and performing desk work.

Surface EMG measurements conducted at the location of the Lumbar Multifidus show different muscle activation patterns when comparing sitting on a CoreWerks technology enabled chair, an Embody chair and a Think chair.



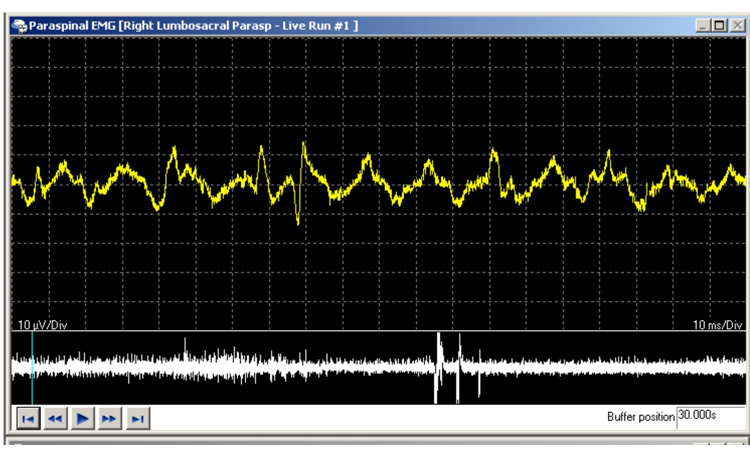
Embody chair

Lower trace shows amplitude of Lumbar Multifidus (L.MF) activation indicating complete relaxation of L. MF



CoreWerks chair.

Showing continuous activation of L.MF. muscle



Think chair:

Small activation of L.MF. muscle

Surface EMG electrodes were placed on the Lumbar Multifidus in the location L4 and next to the spinous process, with the reference electrode placed on the Latissimus Dorsi muscle.

The test candidate was then asked to perform tasks associated with data input into a computer system.

As demonstrated in the screenshots above, sitting on a CoreWerks technology enabled chair shows a continuous activation of the Lumbar Multifidus, as signified by the display of continual muscle activation while sitting and performing work.

Sitting on the Embody chair shows little or no Lumbar Multifidus activation, indicating complete relaxation of the Lumbar Multifidus.

Sitting on the Think chair shows very limited Lumbar Multifidus activation.

These tests show that sitting on a **CoreWerks** Dynamic Therapeutic Technology enabled chair **delivers** on the goal of **stimulating and training core muscles** in an **isolated fashion**.

The research conducted by Hodges et al also supports CoreWerks' finding that the benefits of the technology are experienced immediately, since the recall of the feedforward neuromuscular control patterns which are responsible for the proper timing of the core muscles is immediate as soon as the proper proprioceptive input is provided to the Central Nervous System.

How does the CoreWerks system create its therapeutic benefits of improved core strength for the user?

CoreWerks did not set out to develop a comfortable chair, its design is based on the effort of developing a rehabilitation tool to stimulate the formation of new synapses around lesions in the motor cortex of a child afflicted with Cerebral Palsy induced neuromuscular scoliosis.

The underlying concept is based on a **stroke rehabilitation therapy, Constrained Induced Movement Therapy** that creates the **proper afferent nerve signals by moving the affected limb through the to be relearned movements**, creating the proper stimulus to regrow neural connections around the cortical lesions.

Key to the success of this type of therapy is the **ongoing repetition of the desired movement** such that **neural synapses can form efficiently**. The therapy therefore has to be part of the daily routine.

The objective for the design was to create a system which would encourage the boy, who is the inventor's son, to balance on his own.

Observations made during therapeutic horseback riding, the boy immediately tried to assume a balanced posture on his own, lead to the idea of transferring the benefits of therapeutic horseback riding into a seating system. The CoreWerks Dynamic Therapeutic Technology enabled products are the result of this research and design effort.

In contrast to other systems that try to mimic the benefits of therapeutic horseback riding, like sitting on a Gym ball or "ball based " chairs which make the user experience two pivot points, one at the floor and one at the pelvis , the CoreWerks system is designed to pivot around 1 point located immediately beneath pelvis, as is experienced on a horse.

In addition to having the pivot located immediately beneath the pelvis the system must fulfill a second boundary condition; it must make the user feel safe to avoid triggering the limbic system into the fight / flight mode with the associated tightening of the muscles.

To meet the design goal of providing balancing movements and feeling safe when approaching the limits of tilt, the suspension mechanism is designed to be unstable around the midpoint and to develop a progressively increasing resistance to the tilt, the larger the tilt out of the horizontal plane becomes, creating an “edge” to the tilt.

Following the design intent the system stimulates both the Feedforward and the Feedback Mode of neuromuscular control (as mentioned above). Allowing for small tilt movements around the midpoint the technology activates the spinal and vestibular proprioceptors and provides for an aligned input of both to the CNS as demonstrated by the testimonial listed below.

Through providing the proper afferent sensory input to the CNS, the brain now recalls the proper Feedforward neuromuscular control pattern, feeding it to the cerebellum and to the relevant muscle groups. As soon as the cerebellum receives the proper afferent sensory information it switches into the auto mode, i.e., the Feedback mode of neuromuscular, which runs the process as a reflex and does not require the presence of ongoing cortical control signals to stabilize the sitter. The feedback mode utilizes the deep laying and the mid layer muscles of the trunk, the core muscles, to stabilize the torso, it focuses on the non-volitional muscle structures. For the Feedback mode to work properly it needs a continuous stream of afferent input from the spinal and vestibular proprioceptors to control the stabilizing core muscles. If the afferent stream weakens, the control of the stabilizing core muscles will get weaker and lead to reduced activation, resulting in atrophying and core weakness, making the core prone to injuries.

The CoreWerks system is designed to stimulate the spinal proprioceptors in an isolated fashion and exercise the core stabilizing muscles through the feedback mode. It encourages continuous micro movements that stimulate the spinal proprioceptors including the deep laying paraspinal muscles.

Designing the dynamic platform in this particular fashion leads to another benefit; the spinal and vestibular proprioceptive afferent inputs are, as mentioned above, in alignment, resulting in the optimized sensory motor integration allowing optimized sensory input to the cortex for the learning of new skills and memory formation.

This has been demonstrated using the CoreWerks dynamic platform embedded into a stool for the treatment of kids afflicted with sensory processing disorders like Autism, ADD and ADHD. In all cases the test resulted in an increase of attentiveness.

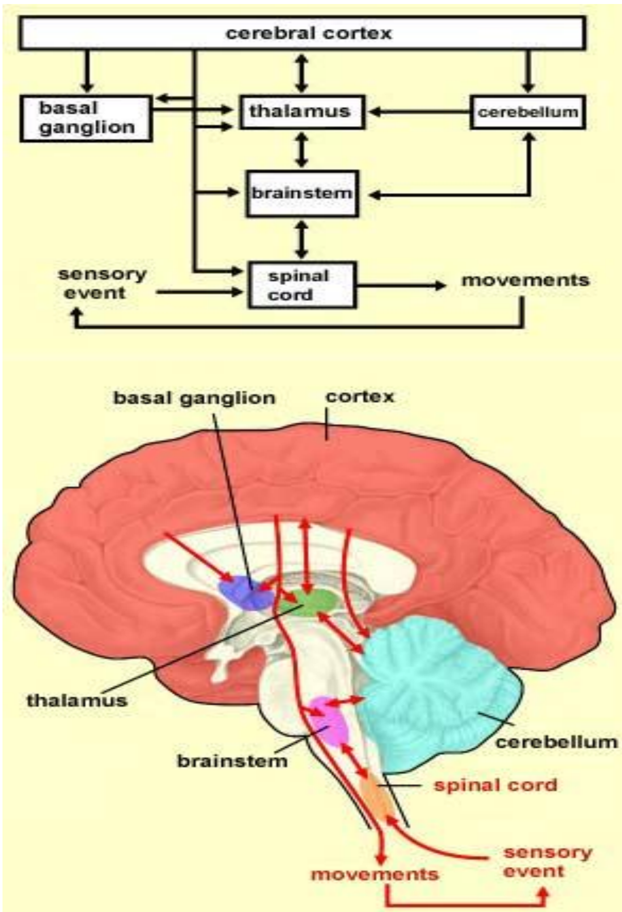
The greatest success rates were experienced by kids seeking sensory input and needing postural improvement leading to the assumption that the system provides the yearned for sensory input and balances spinal and vestibular proprioception.

……….this young man ……….was diagnosed with sensory processing disorder. He was under-responsive to proprioceptive (muscle/joint) and vestibular (movement) input. When he was on the ball, he was able to get the needed proprioceptive input, but it activated his vestibular seeking behaviors. That is when he

would "overload" and jumped so strongly on the ball that when he held a pencil in his hand, he actually popped the ball because of the extreme movement.

L. Witzen, SPD foundation

……. We had one little boy who had a terrible time sitting still. We tried everything we could … and when we tried the stool with him, it was like magic. The family went ga-ga and wants to buy the stool… he is using it at school and home and it has worked like a charm…



So I decided to collect electro dermal activity (sympathetic nervous system) data with him on a chair, a ball, and your stool. Attached is the data we found. It was remarkable. With the chair he goes up and up; with the ball he comes down lower; but with the stool he is the least aroused and settles down……

Prof. Dr. Lucy Miller, University of Colorado, School of Medicine, SPD Foundation

These findings are in line with the work conducted by Dr. Jean Ayres, the pioneer in Sensory integration research.

The diagram shows the information flow between the muscles and processing centers in the CNS. The thalamus acts as a gate keeper for the flow of information to the cortex. The cerebellum controls certain motor activities like an electro- mechanical servo mechanism. A certain movement pattern is downloaded from the cortex into the cerebellum and also sent directly to the relevant muscles. Afferent sensory information is returned to the cerebellum, merged with input from the vestibular system and merged into a control signal used to control the motor activity until a new pattern is sent down by the cortex. The cerebellum also sends some of the control signal to the thalamus and compares it with a control signal from the basal ganglion. The control signal from the basal ganglion controls the smoothness of the movement. If there is a dysfunction of the basal ganglion the system will need increased sensory input to be able to create a smooth movement or transmit sensory information through the thalamus into the cortex.

For the servo system to work properly it will need a continuous flow of afferent sensory information. If the afferent sensory information flow is low the motor control system does not activate the core muscles sufficiently leading to weakening of the core. The need for sensory input is documented by our fidgeting when we sit in a static conventional seating system.

A lack of afferent sensory information flow also leads to a reduction of information flow though the thalamus, reducing your attentiveness.

Conclusion:

Corewerks has developed a novel tool that can be used to treat non-specific low back pain and also certain types of sensory processing disorders. The tool is designed to transfer the benefits of therapeutic horseback riding into seating products of everyday use.

The empirical findings of the company collected since 2004 are now supported by the latest peer reviewed research into the treatment of low back pain, tracing nonspecific low back pain to a partial breakdown of neuromuscular control, which makes nonspecific low back pain a sensory processing dysfunction caused by a lack of sensory input from the spinal proprioceptors. CoreWerks' therapeutic dynamic technology stimulates the spinal proprioceptors and enables balanced sensory motor integration, leading to greater balance and core health. It also can be used to provide the proprioceptive input to the CNS that kids with certain types of sensory processing disorders, especially the ones that are sensory under responsive and posturally challenged, seek for to be able to focus on or attend to a task.