# Mechanisms Proposed to Assist With Lifting

The following mechanisms have been put forth at one time or another to assist in decreasing the flexion moment on the lumbar spine during lifting.

*1) The intra-abdominal balloon mechanism*

***Theory***: This was proposed by Bartelink in 1957 to explain how intra-abdominal pressure could reduce the flexion moment by producing an upward pressure on the diaphragm.

***Faults***: Studies show raises in the intra-abdominal pressure do not correlate well with the intradiscal pressure, lumbar muscle activity or the size of the load to be lifted. The increase in intra-abdominal pressure required exceeds the force capabilities of the abdominals and would obstruct the abdominal aorta. Since the abdominals would be required to contract to produce and increase in intra-abdominal pressure, an increase in flexion moment would be produced.

***Conclusion***: An intra-abdominal balloon effect is not sufficient, by itself, to explain how the flexion moment during heavy lifting is overcome.

*2.) Thoracolumbar fascia tension will produce extensor moment*

***Theory***: Gracovetsky and Farfan hypothesized that the tension produced during abdominals contraction seen during lifting would produce and extensor moment via their attachment to the thoracolumbar fascia.

***Faults***: Dissection revealed that transverse abdominis is the only abdominal muscle that consistently attaches to the thoracolumbar fascia and only its middle fibres. The ransverse abdominis mainly attaches to the middle layer of the thoracolumbar fascia however, lateral tension produced in the posterior layer of the thoracolumbar fascia is what produces extensor moment due to fibre arrangement. Thus subsequent studies have shown that the maximum extensor moment that abdominals can produce on the lumbar spine via the thoracolumbar fascia amount to less than 4% of the required force.

***Conclusion***: The extensor moment produced in the thoracolumbar fascia is insufficient to resist the flexion moment on the lumbar spine on its own.

*3.) The Posterior Ligamentous System Theory*

***Theory***: Gracovetsky and Farfan state that the lumbar spine should remain in flexion during the initial part of lifting to take advantage of the strength of the inert posterior structures. These structures are the supraspinous and interspinous ligaments, capsule of the zygapophyseal joints, posterior longitudinal ligament and ligamentum flavum, posterior layer of the thoracolumbar fascia and the back extensors. The posterior ligamentous system provides connection between the pelvis and thorax and transfer the force from the hip extensors through the lumbar spine so as to can rotate posterior with the pelvis. EMG studies have shown a "Flexion-Relaxation effect" in the back extensors as they become silent as flexion of the lumbar spine increases. If the back muscles contract during this transference of force, they will disengage the tension in the posterior ligaments. As the patient approaches the more vertical posture, the moment arm of the object being lifted would be reduced to the back extensors could produce enough force to extend the lumbar spine to a neutral lordosis.

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***Faults***: Studies of the strength of the posterior ligamentous system conclude that they could not support the moments required to transfer forces from the pelvis to the thorax. The maximum moment they could sustain was four times less than the maximum strength of the back extensors. An anterior shear force from tension in the interspinous ligament will increase zygapophyseal joint compression.

***Conclusion***: The posterior ligamentous system does not seem strong enough to resist the flexion moment required during heavy lifting. However according to Bogduk and Twomey, the passive elastic tension of the back muscles was not taken into account when calculating the posterior ligamentous system strength. Therefore this mechanism could be the possible explanation as to how forces are transferred from the pelvis to the thorax during lifting.

*4.) The Hydraulic Amplifier Effect*

***Theory***: The thoracolumbar fascia may act as a retinaculum for the lumbar extensors and it has been estimated that it may increase the extensors strength by 30%.

***Conclusion***: This is a theory which requires further research as it has only been hypothesized.

*5.) The Arch Theory*

***Theory***: This theory suggests that the lumbar spine can be viewed as an arch supported by the intra-abdominal pressure during lifting. This lends it strength and stability.

***Conclusion***: This is a theory requires further research but has not met with any acceptance to date.

**To Flex or Not To Flex?**

A controversy still exists as to whether a maximal lift should be preformed with the lumbar spine in lordosis or in flexion. From the review of the proposed mechanism to date could be the posterior ligamentous system.

Gracovetsky advocated lifting with a posterior pelvic tilt to flex the lumbar spine and take advantage of the strength of the posterior ligamentous system. This technique of lifting keeps the erector spinae muscles silent during the early part of the lift therefore reducing the compressive forces on the spine. Compression forces are also minimized since the thoracolumbar fascia has the longest moment arm of the inert structures supporting the lumbar spine in flexion therefore it produces the least compressive forces while providing it with the greatest tensile support. During the early part of the lift the inert structures provide resistance to the flexion moment then as the moment arm decreases in length, the mechanism will gradually switch to use the back extensors actively to regain lordosis. The downfall with this technique is that creep in the posterior ligamentous system would require lifts to be preformed at faster paces since static loading and slow lifting increase risk of injury.

When lifting with the lumbar spine in a normal lordosis, the erector spinae muscle activity is greater during the first half of the lift. The contraction of the extensor muscles increases compression on the lumbar spine discs but reduces anterior shear forces acting on the zygapophyseal joint. Maintaining lordosis also decrease the strain on the posterior ligament

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system and posterior annulus (hence McKenzie advocates prophylactic lifting while maintaining lordosis). An interesting concept has been brought forward by McGill, that the longissimus thoracis pars thoracis has the largest extension moment are (approaching 10 cm) and provides a significant extensor moment. This muscle has been overlooked in many studies since it originates in the thoracic spine and therefore this theory needs to be challenged before it can be accepted.

## Clinical Recommendations

Recommendations to patients on the posture of their lumbar spine during heavy lifting should take several factors into account.

Reasons for patients to be taught to lift in **lordosis** include;
- ✧ prior injury to their posterior ligaments including annular fibres
- ✧ intra-articular zygapophyseal joint changes
- ✧ slower, sustained lift required (ligamentous stretch not as much of a concern)
- ✧ good extensor muscle strength and endurance

Reasons for patients to be taught to lift in **kyphosis** include;
- ✧ shares the load between thoracolumbar fascia, posterior ligaments and posterior annulus
- ✧ most energy-efficient technique
- ✧ produced lowest compressive forces on the disc (Gracovetsky)
- ✧ contractile injuries to the back extensor (spares multifidus and erector spinae)

Patients who should avoid all lifting include;
- ✧ disc herniation
- ✧ end-plate fracture
- ✧ acute lumbar injuries

General concepts that can be followed by all patients when lifting are to keep loan as close to their body as possible, use a squat lift, avoid twisting and plan ahead for lifting to determine if they require assistance.

## Take Home Message

Much controversy continues to exist as to the mechanisms that participate in lifting and which technique is the safest way to lift. When teaching a patient how to lift, the best advice would be to prepare the patient for the lift by first improing activation, stabilization and endurance of his / her trunk musculature – then educate on lifting with the lumbar posture that would put the least amount of stress on the patient's injured tissues. If while assessing the patient's lifting, they report symptoms you will have to adjust the lifting technique until you are satisfied they will not be doing themselves harm with lifting. When in doubt – restrict lifting or ask for assistance.

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