# Body Mechanics

*by Joseph E. Muscolino | figure illustrations by Giovanni Rimasti | photographs by Yanik Chauvin*


## To Flex or Extend?

When a client presents with a pathologic lumbar disc, there is a divide in the world of manual and movement therapy: Do we treat the client with flexion or do we avoid flexion and instead treat the client with extension? There are proponents for each method, and unfortunately these proponents often divide along rigid ideological lines, each one believing that their approach is the superior one. As is often the case, whenever two differing treatment approaches exist, usually both are valid. So how do we decide which method to use with the next client who presents with a pathologic disc?

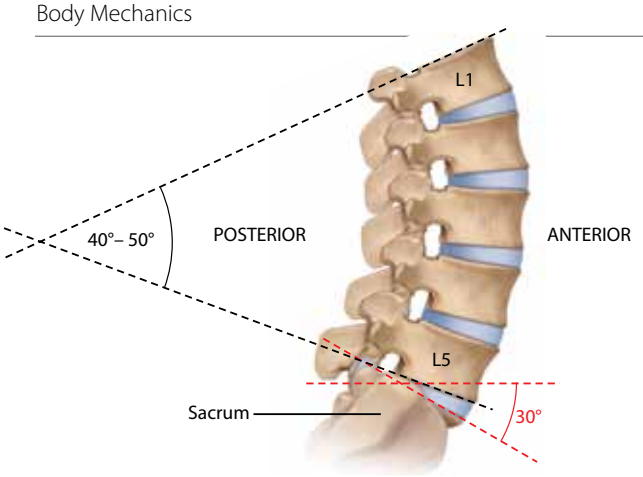



**Figure 1.** The lumbar spine has a normal lordotic curve of approximately 40-50 degrees.

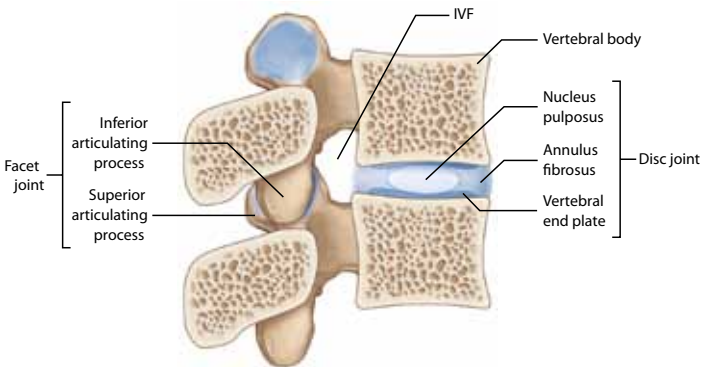



**Figure 2.** Disc and facet joints of the spine. Intervertebral foramen, IVF.

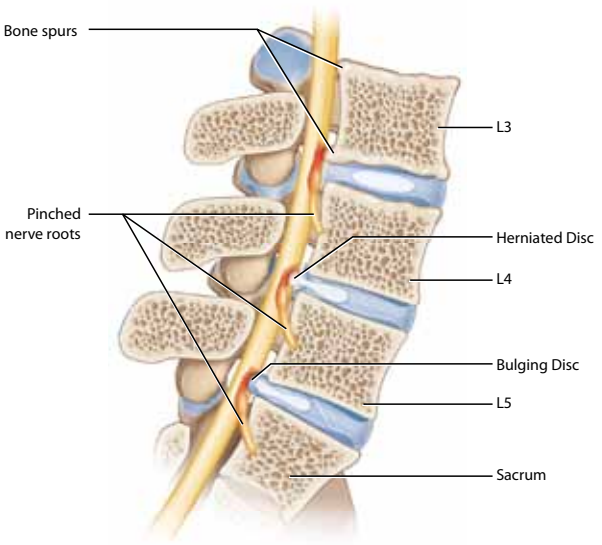



**Figure 3.** Pathologic discs compressing spinal nerves. A bulging disc is seen at the L5-S1 disc and a herniated disc is seen at the L4-L5 disc. Osteoarthritic (degenerative joint disease) bone spurs are seen on the body or L3.

As with all clinical orthopedic work, the answer lies in choosing the correct treatment approach based on the specific pathomechanics of the client's condition and the needs of the client at that moment. Not all pathologic disc conditions are the same, and therefore not all clients with a pathologic disc condition will respond the same. Making the best decision requires a clear understanding of biomechanics, which ultimately rests on a fundamental understanding of musculoskeletal anatomy and physiology, in other words, kinesiology.

*Note: Because a pathologic disc is potentially a very serious condition, with possible permanent effects, it is important to refer any client who presents with this condition to a physician. Referral does not mean that the client cannot also be treated at the same time by a massage therapist. A client with a pathologic disc condition can be under the supervision of a physician and also benefit from massage and other manual therapies.*

## The Lumbar Spine

The lumbar spine is composed of five vertebrae that sit on the base of the sacrum. Because in anatomic position the pelvis/sacrum is anteriorly tilted approximately 30 degrees, there is a natural lordotic curve to the lumbar spine. The healthy lordotic curve varies from individual to individual, but on average is approximately 40-50 degrees (Figure 1).

## Lumbar Spinal Joints

At each segmental level of the lumbar spine, there are three joints: an intervertebral disc joint located anteriorly, and paired left and right facet joints located posteriorly. The disc joint is composed of three major parts: cartilaginous vertebral endplates that cap the bodies of the vertebrae, a fibrous annulus fibrosus that is located circumferentially between the vertebral bodies, and a thick gel-like nucleus pulposus in the center bounded by the fibers of the annulus fibrosus. The facet joints are synovial joints, located between the inferior articular processes of the superior vertebra and the superior articular processes of the inferior vertebra. Each facet joint is bounded by a fibrous joint capsule containing synovial fluid; and the joint surfaces are capped with articular cartilage.

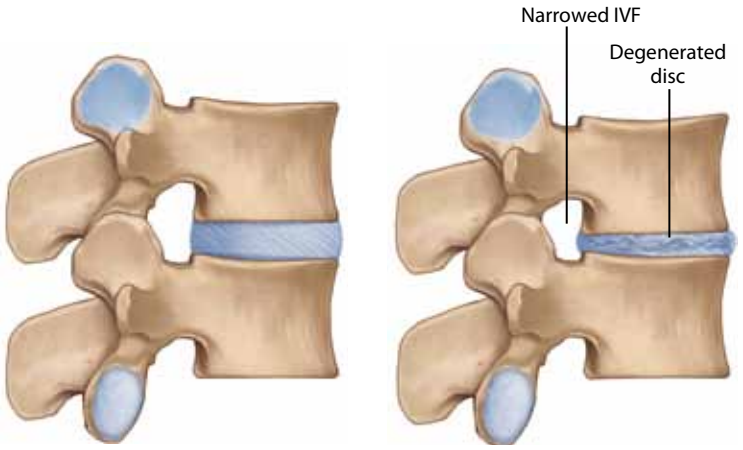
Also located between each two adjacent vertebrae are two intervertebral foramina (IVFs), through which the spinal nerves from the spinal cord pass. An IVF is formed by a notch in each of the two adjacent vertebrae, that when placed together form the foramen for the entry/exit of the spinal nerve (Figure 2).

## Lumbar Joint Function

The degree of motion that exists in any region of the spine is primarily determined by the thickness of the discs, whereas the direction of motion best allowed is determined by the orientation of the fact joints. In the lumbar spine, the facet joints are oriented in the sagittal plane. For this reason, sagittal plane motions of flexion and extension occur freely in this region. From anatomic position, the lumbar spine allows approximately 50 degrees of flexion and approximately 15 degrees of extension. This totals 65 degrees of sagittal plane motion; quite impressive given that this motion occurs across only five segmental joint levels. In addition to motion, the spine is a weight-bearing structure; the lumbar spine must bear the weight of the entire body above it. The disc joints bear approximately 80% of the weight; the facet joints bear the remaining 20%. It is important to note that as weight bears through the disc joint, the nucleus pulposus is compressed, pushing it outward away from the center and against the fibers of the annulus. Weight bearing also affects the facet joints by compressing their joint surfaces.

## Pathologic Disc

When the intervertebral disc is healthy, the nucleus is confined within the fibers of the annulus fibrosus. However, the accumulation of physical stresses to the disc can weaken the annular fibers. These stresses can be macrotraumas such as a car accident or a fall; and/or they can be repetitive stress microtraumas that occur due to such things as poor postures or the ongoing compression force of weight bearing. Regardless of the cause, if the annulus is weakened, weight-bearing compression upon the nucleus can cause it to bulge the annular fibers outward, creating what is known as a *bulging disc*. If the annular fibers are sufficiently stressed, they can rupture, allowing the nuclear material to extrude through the annulus; this is called a *ruptured disc*, *prolapsed disc* or *herniated disc*. Lumbar pathologic discs most often occur in the lower lumbar region, at the L4-L5 or L5-S1 joint levels (Figure 3).




BOX 1

## Degenerated Disc

In addition to bulging and herniated discs, there is third pathologic condition of the intervertebral disc known as degenerative disc disease (DDD). DDD involves breakdown/degeneration of the annular fibers and desiccation of the nucleus pulposus. This results in thinning of the disc, which can be seen on X-ray; the space that the disc occupies between the adjacent vertebral bodies will be decreased in height. DDD is a normal part of aging and is usually asymptomatic. But if it is advanced in degree, it can potentially cause symptoms. Thinning causes approximation of the vertebral bodes, which decreases the size of the IVFs, increasing the likelihood of nerve compression within the IVF (compare the healthy disc in Figure A with the degenerated disc in Figure B). Because DDD involves degeneration of the annulus, it also increases the chance that the annular fibers will weaken and bulge, or perhaps herniate. Interestingly, if the nucleus pulposus is sufficiently desiccated, it exerts less pressure against the annular fibers and the likelihood of a bulging or herniated disc actually goes down. This is why the incidence of nerve compression from pathologic disc conditions decreases in senior citizens.

*Figures courtesy of Joseph E. Muscolino.*

"Ultimately, the goal of all manual and movement therapy is graceful and pain-free functional motion."

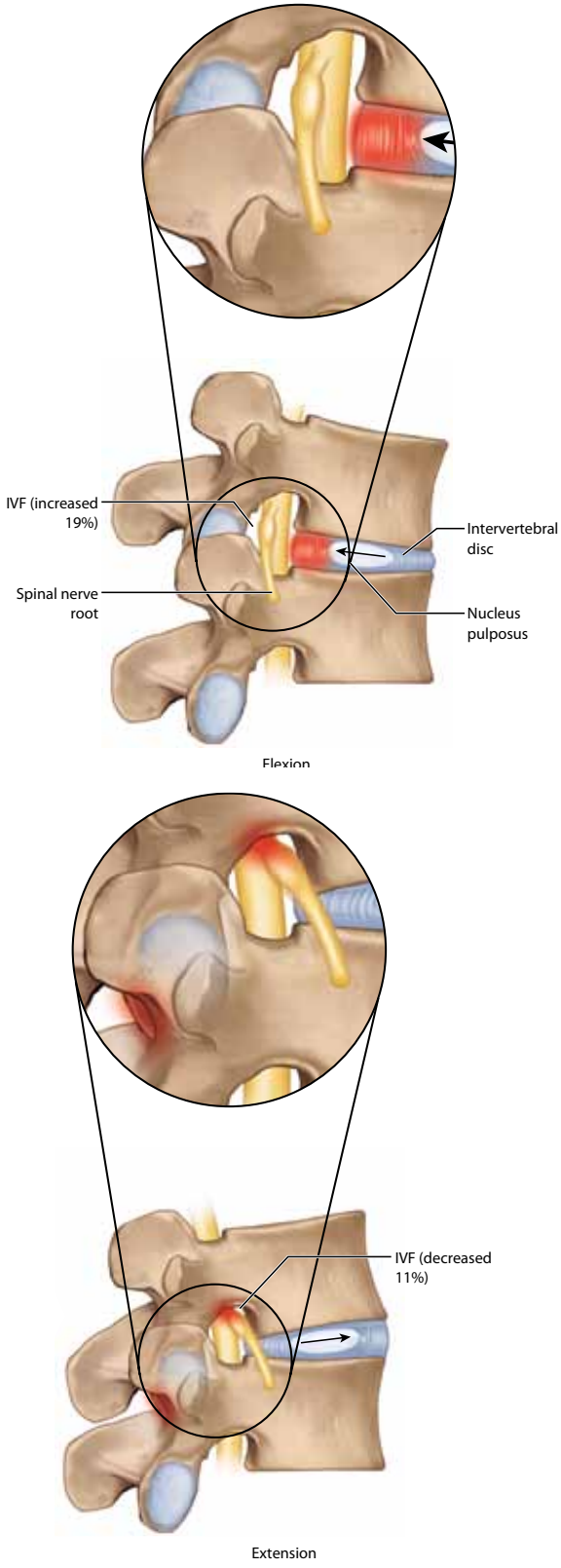



**Figure 4.** 4 A [TOP], Effects of spinal flexion. B [BOTTOM], Effects of spinal extension.

*Figures courtesy of Joseph E. Muscolino.*

Pain from a pathologic disc can occur due to the irritation of local structures, such as the annular fibers themselves or the posterior longitudinal ligament. However, the more serious consequences of a pathologic disc are usually due to compression of neural tissues. Because of how stress forces are usually placed on the intervertebral discs, bulging and herniation most often occur posterolaterally. When this occurs, the disc protrudes into the IVF and can compress the nerve root, causing symptoms into the lower extremity on that side (midline posterior bulges/herniations occur less frequently because the annulus fibrosus is reinforced in the midline by the posterior longitudinal ligament). Because the nerve roots of the lower lumbar spine contribute to the sciatic nerve, pathologic lumbar discs usually cause symptoms of sciatica referring down into the lower extremity.

Therefore, there are two major factors at play when a client has a bulging/herniated disc. One is the disc lesion itself, in other words, the weakened or ruptured fibers of the annulus fibrosis. The second is the encroachment within the IVF of the annulus or nucleus pressing on the nerve. Once the pathologic disc is present, a third factor occurs. Because of the irritation caused by the compression upon the nerve root, it usually becomes inflamed. Given that the IVF is a narrow closed space, there is little chance for the swelling to escape, so it remains in the IVF, further compressing the nerve root. It is often the size of the bulge/herniation plus the swelling that is responsible for the nerve compression and resulting symptoms. It is important to point out that the IVF can also be narrowed due to calcium deposition (bone spurs) at the joint margins; this condition is known as osteoarthritis or degenerative joint disease. When the size of the IVF narrows, it is also described as foraminal stenosis.

## Flexion versus Extension

The question now becomes: What are the mechanical forces of flexion and extension upon the lumbar spine, and how do these forces affect the pathologic disc and nerve compression? It turns out that each movement has positive and negative effects upon the lumbar spine (Box 2, right).

## The Effects of Flexion

The worst effect of flexion upon the lumbar spine is that it compresses the anterior disc. This has two consequences. First, it drives the nucleus pulposus posteriorly against the posterior annular fibers. Second, it pulls the posterior annular fibers taut (Figure 4a). The combination of the tensile force pulling these fibers taut as the

pressure from the nucleus is exerted against them can lead to their degeneration. The fibers begin to fray; and cracks form within them. This can lead to weakening of the posterior annulus and eventual bulging and/or herniation. Unfortunately, most activities of life are performed down in front of us, requiring repetitive flexion movements of the lumbar spine. For this reason, proponents of extension decry the use of further flexion as part of the treatment program for a client with a pathologic disc.

However, flexion also has positive effects upon the lumbar spine. As the lumbar spine flexes, the IVFs increase in size approximately 19%. This can be very helpful if there is compression of the nerve root within the IVF, which usually is a major aspect of a pathologic disc condition.

Another positive effect that flexion has upon the lumbar spine is not directly disc-related, but important none-the-less. Flexion unloads compression force from the facets. This can be important if the client has irritation or inflammation of the facets, common in people who have the typical lower-crossed syndrome marked by excessive anterior pelvic tilt and hyperlordosis of the lumbar spine. However, it is important to note that the presence of compression force upon the facets can indirectly affect the client with pathologic disc. Via Wolff's Law, which states that calcium is laid down on bone in response to physical forces placed upon the bone, compression loading of the facets can lead to osteoarthritic (also known as degenerative joint disease) bone spurs, which can further narrow the size of the IVF, increasing the likelihood that a bulging or herniated disc will cause compression of a nerve root there (See Figure 3).

Of course, if the facets are unloaded, the compressive load that is removed from the facets must be placed

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**BOX 2**

## Positive (+) and Negative (-) Effects of Flexion and Extension Upon the Lumbar Spine

| FLEXION | EXTENSION |
|---|---|
| (-) Drives the nucleus posteriorly against posterior annular fibers | (+)Relieves pressure on posterior annular fibers |
| (-) Places tensile force upon the posterior annular fibers, pulling them taut | (+) Relieves tensile force upon the posterior annular fibers |
| (+) Increases size of IVFs | (-) Decreases size of IVFs |
| (+) Unloads the facets | (-) Loads the facets |
| (-) Loads the discs | (+) unloads the discs |
| (+) Stretches the paraspinal musculature | (+) Strengthens the paraspinal musculature |

somewhere. Given that flexion is an anterior motion, the load is shifted anteriorly onto the discs. In typical anatomic position, the discs normally bear 80% of the weight-bearing load and the facets normally bear the remaining 20%. So not only does flexion preferentially load the anterior discs, it also increases the overall compressive load on the discs.

Flexion has another positive effect: It stretches all posterior tissues of the spine, including the paraspinal (erector spinae and transversospinalis) musculature. Tight paraspinal musculature is often responsible for directly causing low back pain. More importantly for a pathologic disc, if the paraspinal musculature is tight, it pulls in toward its center, thereby creating a compression force upon the discs of the spine. Increasing compression of the discs can then increase nucleus pressure upon the annulus, thereby increasing the size of the bulge or herniation. Therefore, loosening tight paraspinal muscles can benefit a client's pathologic disc.

## The Effects of Extension

The position of lumbar extension places compression upon the posterior disc instead of the anterior disc. This has two important sequelae. First, the annulus is driven anteriorly instead of posteriorly, removing its pressure from the posterior annular fibers. Second, the tensile force upon the posterior annular fibers is removed, so that it is no longer pulled taut. The combination of these two factors can have the direct effect of lessening the degree of a posterolateral bulge or herniation, thereby decreasing compression of the spinal nerve roots within the IVFs.

*Note: Extension will cause the same negative effects upon the anterior annular fibers that flexion causes upon the posterior annular fibers. However, because of the relative lack of extension postures during our life, there is less accumulated physical stress to the anterior annular fibers, and therefore less likelihood of bulging/herniated discs anteriorly. Further, the anterior disc is reinforced by the anterior longitudinal ligament, which is very strong. And even if there were an anterior disc bulge or herniation, there are no neural tissues located anteriorly that would be compressed.*

If the extension position is created by the client actively engaging their extensor musculature to move their trunk against gravity up into extension, there is the added benefit of strengthening paraspinal musculature. This can help to stabilize the spine and protect the discs (and facet joints) from excessive physical stress. Strong paraspinal musculature is also better able to meet the demands placed upon it, lessening the likelihood that it will be overburdened and strained.

However, extension can also have negative effects upon the lumbar spine. Extension decreases the size of the IVF by approximately 11% (Figure 4b). Given that the greatest consequences of a bulging/herniated disc are due to the neural compression of the disc upon the spinal nerve within the IVF, decreasing the size of the IVF could potentially increase compression of the nerve, further inflaming it and worsening the condition.

The position of extension also compression loads the facet joints; as stated previously, via Wolff's Law, this could increase bone spur formation at the facets, which could further decrease the size of the IVF. The upside of this is that loading the facets commensurately results in unloading of the discs. So not only does extension remove loading of the anterior aspect of the disc, by shifting weight-bearing to the facets, it decreases the overall load upon the discs.

## Flexion and Extension Treatment Techniques

If we choose to use flexion as our treatment approach for a client with a pathologic disc, it is typically done by

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**Figure 5** Flexion techniques. A, Therapist-assisted double knee to chest stretch. B, Table that allows for flexion of the spine. C, Self-care double knee to chest stretch. D, Self-care trunk flexion stretch.

*Figures A, C, and D courtesy of Joseph E. Muscolino. Figure B courtesy of Oakworks.*

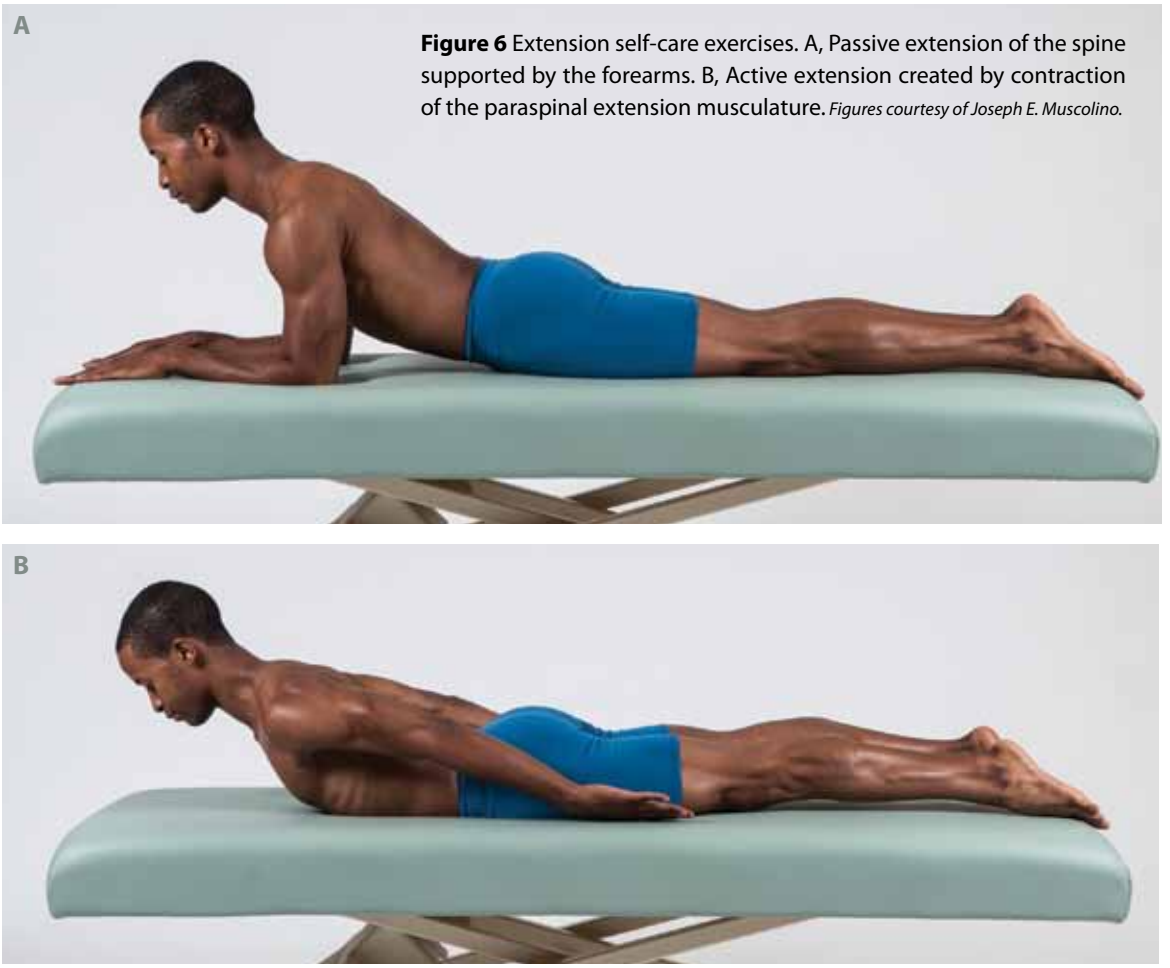


**Figure 6** Extension self-care exercises. A, Passive extension of the spine supported by the forearms. B, Active extension created by contraction of the paraspinal extension musculature. *Figures courtesy of Joseph E. Muscolino.*

performing double knee to chest stretching. By bringing the knees to the chest, the client's pelvis posteriorly tilts, thereby moving their spine into flexion (Figure 5A). Flexion distraction technique is another flexion-based treatment option that is available for those therapists with tables that allow for the caudal (foot) and/or cephalad (head) end of the table to drop (Figure 5B). Regarding self-care directions for the client, either double knee to chest and/or a sitting trunk flexion stretch (Figures 5CD) can be recommended. The benefits derived from flexion are opening up the IVFs and stretching the paraspinal extensor musculature, as well as decompressing the facets.

If we choose to instead treat the pathologic disc client with extension, although it is possible to stretch the client's trunk into extension, it is not logistically easy to do so. For this reason, extension oriented treatment strategy is often based on directing the client to perform self-care stretching and strengthening extension exercises (Figure 6). This approach has been made popular by the physical therapist, Robin McKenzie; for this reason, extension exercises are often called *McKenzie exercises*. The benefits derived from extension are based on relieving stress on the posterior annular fibers and strengthening the paraspinal extensor musculature.

## To Flex or To Extend?

If both flexion and extension positions can be beneficial for the low back, and specifically for a pathologic lumbar disc condition, it brings us back to our original question: When a client presents with a pathologic lumbar disc, do we utilize flexion-based treatment techniques or do we avoid flexion-based postures and instead recommend that the client perform extension exercises for their low back? Looking at the biomechanics of a pathologic disc with nerve compression within the IVF, it would seem that the answer lies in which aspect of a pathologic disc is more problematic for the client when they present: The bulge/herniation of the annulus or the compression of the nerve root within the IVF? This might be a difficult question to answer because neural compression due to a pathologic disc involves both factors, which is why each approach works with some clients, and not with others.

A clue might lie in whether the size of the IVF is decreased for other reasons such as osteoarthritic bone

spurs or the presence of inflammation/swelling. Bone spurs can be seen on X-Ray as well as on CT scan or MRI. If IVF narrowing is occurring largely due to osteoarthritic bony hypertrophy, flexion might be the better course. The more information you have from radiographic findings, the better able you might be to decide whether to use flexion or not. For this reason, it is important to request that the client either give you a copy of the radiographic reports, or you consult directly with their physician. The presence of swelling is more challenging to determine, but as a rule, the more acute and aggravated the condition, the greater the likelihood that swelling is present. Therefore, acute disc episodes might favor a flexion approach.

Conversely, if the client is experiencing a pathologic disc episode that is chronic, an extension approach is more likely indicated. Given that inflammation usually subsides with chronicity, extension would seem to be the wiser choice in the long term because it unloads the posterior annular fibers, decreasing the bulge or herniation. Whichever approach is used to relieve the client's episode in the short run, an understanding of lumbar disc mechanics seems to indicate that extension is the best approach for the long run.

In the absence of detailed radiographic findings and/or other information that would help us make this decision, a default guideline might be to simply choose one approach and follow it for a number of sessions: a period of two to four weeks would be a fair length of time to see if the approach is working. If the client responds favorably and begins to clearly improve, continue with this approach. If the client does not improve, or if the client's condition worsens, then the alternative approach can be tried.

What is most important is to understand the pathomechanics of a pathologic disc condition as well as the (bio)mechanics of flexion and extension as treatment approaches. Working from a fundamental understanding of the kinesiology of the body allows for critical reasoning and therefore creative application of assessment and treatment techniques, which ultimately results in a more successful clinical orthopedic practice! ■

**BOX 3**

## Decompression & Movement

Flexion is problematic because it compresses the anterior spine; and extension is problematic because it compresses the intervertebral foraminal spaces and the facet joints. Therefore, whether flexion or extension is performed, spinal compression occurs. It might be argued that what is most important is not necessarily whether the therapist employs flexion or extension, but rather to avoid compression of the spine. Therefore, with either approach, many therapists recommend that the client focuses on elongating the spine so that it is decompressed. A helpful cue for the client is to ask them to imagine that there is a string that is pulling their head straight up.

It should also be emphasized that movement in most every direction is of paramount importance. No posture is necessarily bad, as long as the client doesn't get stuck in it. The human body is meant to move. Movement works our muscles and joints, stretches and strengthens soft tissues, facilitates neural patterning, and promotes the circulation of body fluids, including a pumping action of the nucleus pulposus so that nutrient supply to the disc tissue of clients with pathologic disc conditions is improved. Ultimately, the goal of all manual and movement therapy is graceful and pain-free functional motion.

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