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A Comparison and Discussion of Flexion and Extension Exercises for the Treatment of Low Back Pain

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A COMPARISON AND DISCUSSION OF FLEXION AND EXTENSION EXERCISES FOR THE TREATMENT OF LOW BACK PAIN

by

Joan Due
Bachelor Of Science in Physical Therapy
University of North Dakota, 1999

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
2000
This Independent Study, submitted by Joan Due in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

[Signatures]

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
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Last, but not least, to my Lord, Jesus Christ, who has given me strength along the way and who makes all of life possible.
ABSTRACT

Low Back Pain is the most common condition that is seen by the outpatient Physical Therapist. The lives of those who suffer from low back pain are negatively impacted in a variety of ways, including monetary expenditures, lost time from work and difficulty performing everyday personal activities. Despite the fact that low back pain is a common malady seen by Physical Therapists, there is little agreement on the management of its symptoms. Perhaps, no two treatments for low back pain could seem so varied as spinal flexion and spinal extension exercises, which seem to be diametrically opposed. This review of the literature discusses both spinal flexion and spinal extension exercises, examines their history, theories and compares the two. The importance of focusing on the impairments caused by low back pain instead of just the diagnosis are discussed and the reader is challenged to use available literature such as the Guide to Physical Therapy Practice to assist him/her when examining these impairments. It is likely that much literature will continue to be available concerning low back pain and it will be necessary to continue reviewing the upcoming research, looking for the most beneficial way to treat all patients with low back pain.
Introduction

Low back pain affects the population of the United States at a tremendous rate. It is the second most common reason a patient will see a physician.\textsuperscript{1} Approximately 80% of all adults will be affected by low back pain during their lifetime.\textsuperscript{2} It has been stated that a first episode of low back pain usually resolves itself in 90% of cases, however, 60-80% of those that experience a first episode will experience reoccurring back pain.\textsuperscript{3} Of these individuals with reoccurring back pain, seven to ten percent will become chronic sufferers.\textsuperscript{4} It is a problem of modern society and its consequences resemble that of a chronic illness.\textsuperscript{5}

The lives of those who suffer from low back pain are negatively impacted in a variety of ways, including monetary expenditures, lost time from work as well as difficulty performing every day personal activities. The costs of low back pain result in a 20-50 billion dollar annual cost to society.\textsuperscript{6} Less than 50% of individuals disabled by low back pain for six months or more ever return to work and for those that are disabled for two years or more the return to work rarely happens. This impacts not only the workplace but the individual dealing with back pain and society as well.\textsuperscript{7}

Physical Therapists will need to deal with the problem of low back pain frequently. It is the most common condition that is seen by the outpatient physical therapist in the United States. It is estimated that 25% of the caseload in an outpatient setting is for low back pain.\textsuperscript{8}
Despite the fact that low back pain is one of the most common conditions seen in a physical therapy clinic, there is usually little agreement among therapists when it comes to the management of its symptoms and rehabilitation.\textsuperscript{9} There is generally no commonly accepted assessment of low back pain and the treatments available are of many ideologies. It has been stated that "treatment practices are driven in a great part by attitudes and beliefs of individual practitioners."\textsuperscript{10}

Despite the fact that physical therapists are varied in their treatment for low back pain, there is now a consensus on an appropriate starting point. This starting point is to encourage the patient with low back pain to exercise and avoid prolonged bed rest. Bed rest, which used to be the mainstay of treatment of low back pain, is not only no longer the treatment of choice, but also has been found to compromise recovery.\textsuperscript{11,12}

What are the options then for treating low back pain with exercise? There are two main schools of thought that have been widely used when creating exercise programs for persons with low back pain. These are spinal flexion and spinal extension exercises.\textsuperscript{13} These exercises, both commonly used are contradictory in theory and practice.\textsuperscript{14}

This paper will review the anatomy and causes of low back pain. It will also compare the theories and results of spinal flexion and extension exercise, discuss the comparisons and introduce another treatment documented in the literature that may be helpful now or in the future.
To better understand low back pain and how it affects the human body, it will be necessary to review the anatomy of the low back. The anatomy of the low back, for the purposes of this topic, will include the lumbar spine and sacrum. The lumbar spine consists of five vertebrae and their intervertebral discs and five pairs of spinal nerves. A number of joints and ligaments are also included in the lumbar spine increasing flexibility and stabilizing the spine.

Vertebrae of the lumbar region have a massive body. Due to this increased height, greater flexion and extension is allowed in the lumbar region when compared to most other areas of the spine. Extension is somewhat limited though, because of the contact of the thick horizontal spinous processes and orientation of the facet joints that are located on the posterior portion of the vertebrae.\(^6\) (Figure 1)

Each lumbar vertebra consists of an anterior and a posterior portion. The anterior portion has the job of weight bearing while the posterior portion mainly guides movement.

The anterior portion of the vertebrae, the vertebral body, consists of an outer layer of cortical bone that surrounds an inner layer, made up of spongy bone.\(^15\) This spongy bone, called trabeculae, is made up of vertical and transverse thin rods of bone. It is much less dense than the cortical bone, which makes up the outer layer of the vertebral body. The trabeculae also allow room for blood flow and venous draining. This extra
Figure 1. Typical Lumbar Vertebral Body. Anterior view (top) and Side view (bottom)
fluid in the bone, in turn, is helpful in transmitting applied loads and force in weight bearing. The posterior portion of the lumbar vertebrae consists of a vertebral arch, two pedicles and two laminae. The vertebral arch houses the spinal cord and nerve roots and protects them. The posterior portion of the vertebral arch consists of the spinous process and the posterolateral portions consist of two transverse processes. These processes extending from the vertebral arch allow a place for the deep back muscles to attach and obtain leverage during movement.  

The pedicles, on the posterior portion of the vertebral body, project out of the superior portion of the body. They connect the vertebral body and the posterior portion of the vertebrae while playing a very important role in transporting forces between them. The other area of the posterior portion of the vertebrae, the lamina, forms the roof of the neural arch. These two lamina then continue to form the spinous process at the very back of the vertebrae. 

The intervertebral discs, the main shock absorbers between each lumbar vertebrae have a very important role. These discs make up 33% of the height of the lumbar spine. They are very strong and play a leading role in weight bearing, however their role in movement is also very important. They are able to be deformed and can accommodate for rocking movements. These movements allow for increased flexion, extension and lateral bending in the lumbar spine. The discs consist of an inner cortex, outer layer and a vertebral end plate on the top and bottom aspects of each disc. 

The inner layer of the vertebral disc, the nucleus pulposus, is a semi-fluid mass of mucoid material that can be deformed under pressure. The volume however, cannot be compressed and this allows for it to return to its original shape after movement. It has a
high water content which decreases with age.\textsuperscript{6} The average water content of the nucleus pulposis is 88 percent at birth and decreases to 65-72 percent by the age of 75. Loss of water in the nucleus also occurs due to sustained loads caused by muscle contraction, ligamentous prestress, body weight and ground reaction force. Muscle contraction results in the largest compressive force to the intervertebral disc, especially during postures and movements of the spine influencing interdiscal pressure.\textsuperscript{7}

The outer layer of the vertebral disc, the annulus fibrosus is made up of collagen fibers arranged in sheets called lamellae. These arranged sheets are thicker in the anterior and center of the disc and thinner in the posterior portion of the disc. With age the annulus fibrosus fibers deteriorate and lose their capacity to contain the nucleus pulposus. This deterioration leads to an increased risk of a herniated disc with age.\textsuperscript{15}

The top and bottom of each vertebral disc also consists of a vertebral end plate, which is loosely attached to the vertebral bodies and acts as a barrier for the nucleus pulposus.\textsuperscript{17} This endplate is made up of two layers of cartilage which covers the total nucleus pulpous and all except the periphery of the annulus fibroses, allowing for distribution of the hydrostatic pressure placed on it by the nucleus pulposus.\textsuperscript{6}

There are three types of joints in the vertebrae of the lower back; fibrous joints, cartilaginous joints and synovial joints. The fibrous joints are those ligamentous connections between the lamina, spinous processes and transverse processes of two vertebrae. The cartilaginous joints are those between the vertebral bodies and the vertebral discs. The synovial joints, known as the zygapophyseal joints or the facet joints, allow for gliding movements between the vertebrae. These joints are also responsible for bearing some weight in the lumbar region.\textsuperscript{6} The inferior articular process
of one vertebrae and the superior articular process of the vertebrae below form these synovial joints. Each of the articular processes is covered with hyaline cartilage which increases the load bearing ability of these joints.

There are seven ligaments found in the lumbar spine that will be discussed. These ligaments are the anterior longitudinal ligament (ALL), the posterior longitudinal ligament (PLL), ligamentum flavum, interspinous ligament, intertransverse ligament, supraspinous ligament and the iliolumbar ligament. They are all flexible enough for movement, however, allow for stabilization of the joint as a source of afferent tissue to the central nervous system. Significant damage may lead to instability and decreased proprioception increasing the risk for altered movement patterns.

The ALL runs longitudinally from the cervical region down to the sacrum. It attaches primarily to the anterior aspects of the lumbar vertebral bodies. It runs longitudinally and resists separation of the anterior portions of the vertebral bodies. This, in effect, prevents hyperextension of the lumbar spine.

The posterior longitudinal ligament also extends from the cervical region to the sacrum. This ligament attaches to the disc only and narrows in the lumbar region. It resists hyperflexion of the spine in the lumbar region and helps prevent posterior propulsion of the nucleus pulposus of the disc. As the PLL descends the spine it begins to narrow at L5, and becomes only one half of its normal width by the time it reaches L5. This narrowing of the PLL causes the ligament to be weakest in the lumbar area, decreasing the protection to the movement segment and increasing the risk of disc herniation. Disc herniation above L4-5 is uncommon and 90 percent of disc herniations occur at L5-S1, the area where this ligament is the most narrow.
The ligamentum flavum as a whole, also runs from the cervical region to the sacrum. However, this is a short ligament and joins the lamina of consecutive vertebrae. It attaches inferiorly to the outside of the lamina and superiorly to the inside edge of the lamina. It is found equally on both the right and left sides of the spine.\textsuperscript{15} It is also the only ligament of the lumbar spine that consists of mostly elastic fibers (80\% elastin, 20\% collagen).\textsuperscript{16} These features help prevent buckling in the ligament and protect the neural elements inside the spine during movements in all directions.\textsuperscript{16}

The intertransverse and interspinous ligaments are attached between transverse processes and spinous processes respectively. These ligaments are both well developed in the lumbar region only with the intertransverse limiting sidebending and the interspinous limiting flexion.\textsuperscript{16}

The supraspinous ligament runs from the cervical area to the sacrum also. It runs from the posterior edge to posterior edge of the lumbar vertebrae and is well developed only in the upper lumbar region. It is difficult to identify this ligament because it merges with the insertions of the other lumbar muscles.\textsuperscript{16}

The iliolumbar ligament is present bilaterally. These attach the transverse process of the fifth lumbar vertebrae to the illeum. This ligament prevents forward sliding of the L5 vertebrae on the sacrum.\textsuperscript{16}

The muscles of the low back region consist of three groups: the superficial, intermediate and deep. The superficial and intermediate muscles of the back include the trapezius, latissimus dorsi and the serratus posterior. These muscles are mostly involved in limb movements and respiration.\textsuperscript{6}
The deep muscles of the back are those that are mostly involved in spinal movement and posture. These are further divided into three layers: The superficial layer, the intermediate layer and the deep layer. The superficial layer of the deep back muscles includes the splenius capitus and the splenius cervicis, both which are involved with the thoracic and cervical regions only. The intermediate layer is the Erector Spinae muscle, which is further divided into three longitudinal columns. These three columns include the iliocostalis, which is the lateral column, the spinalis, which is the medial column, and the longissumus, which is between the two. These three muscles are all attached to the iliac crest through a common origin and are the principle extenders of the spine. The deepest layer of the deep back muscles includes the semispinalis, multifidus and rotatores. The semispinalis muscle is located in the thoracic and cervical regions and does not extend into the lumbar area. The multifidus muscle extends from S4 to C2. It has fibers that run from lateral to medial on the spine, from the vertebral arch to the spinous processes spanning between one to three vertebrae. Both of these muscles are capable of extending the trunk, laterally flexing the trunk and rotating it to the opposite side. The rotatores extend the length of the vertebral column. Their fibers run from the transverse process of the inferior vertebrae to the spinous process of the vertebrae above. This muscle rotates the vertebrae above to the opposite side and also stabilizes it.6

The sacrum is a triangular shaped bone just inferior to the vertebral column. It consists of five fused vertebrae, S1 through S5. The sacrum supports the vertebral column. It transmits loads from the trunk to the lower limbs.16 It also provides strength and stability to the pelvis.6 The sacrum contains the sacral canal which is a continuation of the vertebral canal. It runs the entire length of the sacrum and opens through the sacral
hiatus.\textsuperscript{16} The sacral hiatus is located in the inferior, posterior portion of the sacrum and results from the absence of the lamina and spinous process of S5.\textsuperscript{6}

The low back and its many component parts must work together correctly while performing movements or dysfunction will result. If one or more components of this complex structure is damaged or not working correctly, low back pain may occur many times leaving an individual unsure about what has happened in their back. The causes like the anatomy are varied, complex, and their resulting impairments will have a large impact on the functional status of an individual.
Causes of Low Back Pain

The economic impact due to low back pain continues to grow both in prevalence and in the cost to society. Treatment is difficult in part due to the complex anatomy of the low back and to the numerous causes of low back pain which vary significantly. It has been stated that a clear cut diagnosis for low back pain is an impossibility. Much research has been performed with a wide array of literature available about low back pain, however, little consensus has been achieved as to the underlying causes of low back pain and this has contributed to the difficulty in implementing treatment plans.

The causes of low back pain will be introduced and some clinical symptoms of each will be reviewed. The causes will then be categorized according to a recent tool used by Physical Therapists today, the Guide to Physical Therapy Practice. The Guide to Physical Therapy Practice was developed to assist Physical Therapists in analyzing their patient/client management and describe the scope of their practice in 1997. It has become widely used and is a tool for many types of individuals including; Physical Therapists, Physical Therapy students, health care policy makers, administrators and third party payers. Due to the complexity of the back and the difficulty in diagnosing low back pain, it may be important to broaden our view when looking at the causes of low back pain and how we treat it. The Guide to Physical Therapy Practice has done that. It has rejected the theory of treating only the diagnosis and replaced it by focusing on the
process of disablement caused by the diagnosis and how it impacts function. It divides practice patterns into four major categories: Musculoskeletal, Neuromuscular, Cardiopulmonary and Integumentary. These four categories are further broken down into many subdivisions of practice patterns. It is within these practice patterns that we find our diagnosis. Most of the diagnoses of low back pain occur in the musculoskeletal category however low back pain does impact many body systems and will be found throughout all the categories of the Guide to Physical Therapy Practice. For this review, it will be important to note the causes of low back pain and examine each cause and determine how it affects the low back.

The Musculoskeletal section of the Guide to PT Practice contains many causes of low back pain. These include diagnoses that affect the structure of the vertebrae itself such as osteoporosis, degeneration of the intervertebral disc, ankylosing spondylitis, pathological fractures and spinal stenosis.

Osteoporosis, a bone disease in which the rate of bone reabsorption is greater than bone deposition is a common cause of low back pain. The skeletal structures are weakened and fractures occur with minimal trauma. The presenting symptoms of these fractures will be a dull, nagging pain in the back. The backache will be intensified by activity and somewhat relieved by rest.

Degeneration of the vertebral disc may occur due to spondylolisthesis. Spondylolisthesis, caused by a defect in the pars articularis, occurs when the body of a superior vertebra slips forward or backward on an inferior vertebra. The majority, 70% of these defects are caused by the forward slipping of L4 on L5. The most common symptom of spondylolisthesis will be low back pain that may radiate into the sacroiliac
region. The pain usually does not follow any dermatomal pattern and is usually felt as more of a parasthesia rather than pain. Limited flexibility is often noted on examination and a palpable ledge is felt at the affected segment. There may also be a segmental lordosis, which is painful when external pressure is applied. Hamstring extensibility may also be limited.¹

Ankylosing Spondylitis is another common cause of low back pain. It has an insidious onset and has no clear clinical presentation making it difficult to differentiate from other back pain in the beginning stages. Some of the clinical symptoms assisting with the diagnosis of this disease are: morning stiffness, progressive spinal movement limitations and deformities and exacerbations and remissions of low back pain. It affects synovial and fibrous joints causing pathological changes such as chronic synovitis leading to cartilage destruction, erosions and sclerosis of underlying bone. Fibrosis and ankylosing of the affected joints occurs with the sacroiliac joint being affected 100% of the time. The intervertebral discs and the symphysis pubis are also frequently involved. The patient may complain of unilateral pain, which is referred to the buttocks. This may cause the diagnosis to be confused with a ruptured disc however there will be an absence of neurological signs.¹

Fractures of the lumbar vertebrae may be due to various causes. A wedge compression fracture of the vertebral body may cause persistent pain. If the vertebral body is crushed less than 50% of it’s height, it can return to full function whereas if the crush is greater than 50% of it’s height a segmental fusion will most likely be required.¹⁵

Spinal stenosis is a narrowing or constriction of the spinal canal. It is usually irreversible and progressive. The chronic compression of nerves in the cauda equina
leads to neurological symptoms and may be exacerbated by activity. The patient may experience claudication, which is relieved after several minutes of rest and is better in flexed postures. The patient presents with back pain and symptoms in the legs that include heaviness, bilateral weakness and cramping.\textsuperscript{1}

The Musculoskeletal section of the Guide to PT practice also includes diagnoses in which the supporting and soft structures of and around the lumbar vertebrae are affected. These include such diagnoses as; degeneration of the intervertebral disk, muscle strains of the lumbar area and sprains and inflammation of the sacroiliac region.\textsuperscript{20}

Degeneration of the intervertebral disk due to the aging process, results in the loss of fluid in the nucleus pulposus and a weakening of the annulus. This degeneration can cause not only segmental instability, but also excessive flexion and extension at the involved segment. Due to this abnormal movement at the involved segment, excessive strain is experienced by the outermost fibers of the annulus.\textsuperscript{15}

Muscle strains of the back are very common. They account for 60-70\% of people experiencing back pain due to a mechanical disorder. Pain associated with a muscle strain is non-radiating and associated with a mechanical stress of the lumbar spine. The cause of back strain, though not clearly known, is related to a ligamentous muscle strain due to either continuous stress of a specific episode. During flexion and extension movements of the lumbar spine, tension is created in the paraspinal, hamstring and gluteal muscles along with the ligaments in the vertebral column. This stress is accentuated during heavy lifting. If the stress is greater than what the supporting structures can withstand or if the supporting structures are abnormal, low back pain will result.\textsuperscript{2}
Pain caused by back strain is also related to posture and is mostly attributed to hyperlordosis. Hyperlordosis increases stress on the spine's supporting structures affecting not only the facet joints and spinous processes, but also may cause nerve root irritation. After a muscle strain of the back, low back pain will be the major complaint. It will be either local or diffuse and may intensify after the injury due to increased edema in the area. Some motions may continue to be painless but others will produce disability.2

Dysfunction at the sacroiliac joint includes sprains and inflammation. A sacroiliac sprain, occurring at the lumbosacral junction, is known to be a common cause of backaches. Sprain in this region was introduced as a cause of low back pain by Goldthwaite as early as 1905. The symptoms for a sacroiliac sprain are a backache, pain over the sacroiliac joint, and tenderness over the joint during palpation. The disc can also refer pain to the sacroiliac joint region and it will be necessary to rule out disk pathology.15

The findings seen with a sacroiliac sprain include pain on resisted leg abduction, tenderness over the lower one third of the sacroiliac joint and the pubic symphysis, and a trendelenburg gait may develop due to gluteal inhibition.15

The sacroiliac joint is normally very stable and is reinforced by the interosseous, iliolumbar, sacrotuberous and sacrospinous ligaments. Instability is rare and if found, there is usually a history of trauma that disrupts the pelvic ring. The pain caused by trauma is usually disabling and can be treated only by sacroiliac fusion.15

Sacroiliac inflammations also present as back pain and can affect the synovial and fibrous joints. These inflammations can cause destruction of cartilage and sclerosis.
of bone. The symptoms usually have an insidious onset and are marked by remissions and exacerbations. The pain may refer to the buttocks and thigh, however, there is an absence of neurological symptoms. \(^{15}\)

All of these causes of low back pain, though different, are found in the same category in the Guide to Physical Therapy Practice. This is due to the similarity of their resulting impairments which many times are musculoskeletal in nature. The treatment and goals for these diagnoses are also very similar depending on the severity of the pathological processes and are found in the same practice pattern subdivision. An example would be Ankylosing Spondylitis and Lumbar Sprains. Though these are two very different diagnosis, they are both found in the practice pattern subdivision of Impaired Joint Mobility, Muscle Performance, and Range of Motion Associated with Ligament or other Connective Tissue Disorders. They both have very similar treatment approaches such as decreased pain, increased mobility, strengthening, and increased stability of the spine. Clinicians will see the goal to be accomplished by looking at the impairment and use the diagnosis to lead them in specific treatments to reach those goals.

The second section of preferred practice patterns in the Guide to PT Practice is the Neuromuscular section. This includes diagnoses that are causes of low back pain such as abdominal aneurysms, infections of spinal cord, herniated intervertebral discs and neoplasms. \(^{20}\)

An abdominal aneurysm may cause low back pain. It occurs when a vessel wall becomes weakened. It may rupture in several places, however the area just below the kidney is the most common. The symptoms include abdominal pain with both intense
back and flank pain, along with a pulsating abdominal mass. This diagnosis will need immediate medical treatment with repair of the abdominal aorta deemed necessary.21

A spinal infection is usually linked to an infection of the genitourinary system and has an insidious onset. A backache is the most common symptom early on and is not really different from a mechanical backache. The progression of pain, however, becomes constant and increases at night. All movements of the spine will intensify pain and the hamstring and paravertebral muscles may experience severe spasms. As the infection worsens, gross spinal rigidity will occur with the spinous processes being tender to pressure. The patient will appear sick, have a fever and an elevated white blood cell count.15

Disk herniation is also a very common cause of low back pain. It occurs when the nucleus pulposus protrudes through the fibers of the annulus fibrosis.2 Most ruptures occur before a person is 50 years old and rarely affects more than one segment simultaneously.15 The most common levels for disc herniation are at the L4-5 level and the L5-S1 level. Disc herniations usually put pressure on the corresponding nerve root and will cause pain that radiates down the leg in the distribution of the affected nerve root. There are different levels of disc herniation with disk protrusion being a disk bulge in which the annular fibers are still intact and attached to the vertebral body. A disc extrusion is different in that the nuclear material is not contained in the annulus and the vertebral end plates are at a great risk for rupturing.2

These diagnoses cause impairments that place them in the Neuromuscular category. In this category the medical problems will need to be taken care of first before the resulting impairment will be addressed. These resulting impairments, though in a
different category then the first will be treated with many of the same approaches as the Musculoskeletal group. For example, disk herniation is likely to cause Impaired Posture and decreased mobility of the spine just as many of the symptoms in the previous group.

The Cardiopulmonary category of preferred practice patterns contains no new causes of low back pain so new diagnoses will not be addressed here. It is interesting to note that impaired posture, an impairment in the Musculoskeletal category may very well be causing Impaired Aerobic Capacity, an impairment in the Cardiopulmonary category. Many of the treatments here will also be similar.²⁰

The Integumentary section of preferred practice patterns contains some diagnoses that have not been mentioned before and may be a cause of low back pain. These include the diagnosis of abrasions and contusion.²⁰

Trauma to the muscles of the low back causes a soft tissue injury, which activates the muscle nociceptors causing low back pain. Muscle pain of the low back is often diffuse and ill defined with a dull, aching characteristic. The tissue damage may be temporary and allow for a full recovery.²¹

Many diagnoses have been examined here and have been found to have very similar, if not identical presenting symptoms at times. It is no wonder that health care individuals have difficulty with diagnosing these causes of low back pain and coming up with appropriate treatments. Perhaps the idea of looking at the disablement model will be a viable alternative plan. This review will examine two common diagnoses and see how they fit into the Guide to Physical Therapy Practice.

Osteoporosis, a common disease, causes demineralization of bones. This diagnosis is found only into the Musculoskeletal category in the Guide to Physical
Therapy Practice. It does however fit into five different subdivisions of practice pattern depending on the impairments that are presenting.

The first subdivision for osteoporosis is Primary Prevention/Risk Factor Reduction for Skeletal Demineralization. The guide includes tests and measures for this pattern, the prognosis and the expected range of number of visits along with a variety of other pertinent information. Interventions are given with anticipated goals of therapeutic exercise and functional training in self-care, community and work integration. These include such goals as improving postural control and independence in activities of independent living (ADL’s) and Independence in Activities of Daily Living (IADL’s) along with many others. The second subdivision that osteoporosis is found under in the musculoskeletal category is Impaired Posture, a more progressive impairment. This practice pattern subdivision includes a prognosis and expected range of number of visits also, though they are different from the previous subdivision. Interventions are also given in therapeutic exercise and functional training where goals such as decreased pain, improving joint integrity and mobility and reducing the risk of reoccurrence are found. Some of the goals found in this subdivision of practice pattern are the same as those found in the previous subdivision and include increasing postural control and independence in ADL’s and IADL’s as before.20

The diagnosis of osteoporosis is found in three more subdivisions of practice patterns: Impaired Muscle Performance; Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion associated with Capsular Restriction and Impaired Joint Mobility, Muscle Performance, and Range of Motion associated with Fracture. All of these subdivisions of practice patterns include a prognosis, expected
range of number of visits and intervention containing goals in different areas. These goals are specific to the degree of impairment caused by the diagnosis and will focus on the areas that need to be addressed within each impairment subdivision. Improved posture and increased independence in ADL’s and IADL’s are considered as goals in all the subdivisions where osteoporosis is found, along with many other goals that are the same or similar. Each diagnosis will likely result in an impairment which is dependent on the severity of the disease.

An alternative, due to the many similarities of goals, when treating patients with low back pain is to not focus on their diagnosis, but to instead focus on halting the impairment and increasing function for these patients. We will still always need to take into account the individuality of each patient, looking at their diagnosis to identify the structures involved and to guide us in the specifics of treating each resultant impairment. We know however, and can see through the Guide to Physical Therapy Practice that one specific diagnosis for low back causes many impairments which may be similar or even the same to those presenting with another cause of low back pain.

Examining another common diagnosis, degenerative disc disease, the same concept is found. Though it is only one diagnosis, it is found in many subdivisions of practice patterns due to the many impairments it causes. It is found in six subdivisions of preferred practice patterns in the Musculoskeletal category and also jumps across a category to be found in the neuromuscular category. Many of the goals for degenerative disc disease are also the same or similar across practice patterns. The interesting concept is that the goals found for this disease are many times the same as they were for osteoporosis, due to them being found in some of the same practice patterns. It is easy to
see that when treating low back pain caused by many different diagnosis and pathological processes we may be seeing very similar impairments. It will be important to keep impairments in mind and work to gain the very highest function possible for patients when deciding which exercise to prescribe for low back pain.
Discussion of Flexion Exercises

There are many different exercises for the treatment of low back dysfunction such as manipulation, cranial sacral therapy, spinal stabilization and spinal flexion and extension exercises. One of the oldest that are still used today is spinal flexion exercises.8

It would be difficult to examine flexion exercises without mentioning Paul C. Williams. He described the first structural approach to rehabilitating patients with low back pain.11 His approach was developed to bring about a permanent reduction of lumbar lordosis. It included fitting a patient in a Plaster-of-Paris cast, which maintained the patient in a flexed position. This cast was to be worn for one to two weeks along with bed rest, which was prescribed for approximately ten days for most patients. The patient would then receive a brace, which maintained this position of decreased lumbar lordosis. The brace was usually to be worn four to six months and the patients would also be instructed in postural exercises to decrease the lordosis at that time.22 Many of the treatments for low back pain today can be traced back to William’s article "Lesions of the Lumbosacral Spine". Williams reported his findings in this article after performing a study of 1000 chronic low back pain patients. He concluded that low back pain was a result of "humankind’s" lumbar lordosis.8 He developed a treatment program including bed rest, bracing and flexion exercise to reverse the lumbar lordosis and increase abdominal strength in his patients.13
Williams thought, that due to the sedentary nature of the lives of most adults the spinal flexors, especially those in the abdominal region, weaken. He believed that because of overuse, the spinal extensors will become too strong and upset the balance between the spinal flexors and extensors. Williams also believed that because mankind had forced his body to stand erect, the weight on his vertebral column was distributed to the posterior part of the intervertebral disc. This increased weight bearing at the posterior portion of the lumbar disc caused many intervertebral disc ruptures, especially at the fourth and fifth lumbar levels. The ruptures of these discs cause the nuclear material to move into the spinal canal and cause pressure on the spinal nerves due to the limited space at the intervertebral foramen. This in turn leads to low back pain in most individuals. Williams proposed that his rupture of the disc usually occurs at the fifth lumbar vertebrae and occurs in most people by the age of twenty. He stated that bouts of mild back pain can be attributed to a ruptured disc.

Other studies have been done that agree with the concept that the posterior portion of the intervertebral disc is the first to be destroyed. This adds credence to the idea of using flexion exercises for the treatment of low back pain.

William's theory behind using flexion exercises for treating pain of the low back is that with increased flexion and reduced lumbar lordosis, the intervertebral foramen will be further opened and there will be decreased compression of the spinal nerves. This decreased pressure will decrease the loading of the posterior portion of the intervertebral disc and will reduce discogenic symptoms. Williams believed flexion exercises could also be used to prevent individuals from reoccurrences of low back pain.
by inducing postural change to relieve the pressure on the posterior components of the back.\textsuperscript{11}

The use of flexion exercises for treatment of low back pain was also strengthened when it was reported in studies that abdominal pressure is linked to intervertebral pressure.\textsuperscript{11} Interabdominal pressure has been investigated as a factor in supporting the lumbar spine. It is thought that increased abdominal pressure causes a thrust under their diaphragm, which can be transmitted to the thoracic spine and shoulders through the ribs. This transmitted pressure provides partial support and decreases the load in the spine while lifting.\textsuperscript{25}

Other, more current research, endorsing the importance of abdominal strength has been seen in the literature. This research has indicated that the deep abdominal musculature, namely the internal oblique and the transverse abdominus, has been found to undergo changes in their functional performance in patients with chronic low back pain.\textsuperscript{26}

William's program that was used to treat low back pain consisted of exercises that would develop the muscles used to flex the lumbosacral spine and stretch the lumbosacral extensors. They included such exercises as sit-ups with arms outstretched and sit-ups with arms crossed, pelvic tilt, knee-to-chest and toe touches.\textsuperscript{25}

Many forms and variations of William's exercises have been seen in the clinic. They will likely continue to be seen as long as clinicians receive positive results.
Discussion of Extension Exercises

The treatment program for low back pain, using spinal extension exercises are vastly different from that of spinal flexion exercises. Extension exercises focus less on the disc itself, instead focusing on the muscles, ligaments and other soft tissues around them. One of the stark differences between spinal extension and spinal flexion exercises is that while spinal flexion exercises have a goal of increasing spinal flexion, spinal extension exercise include the goal of maintaining the natural lumbar lordosis to decrease shortening of tissues around the disc.27

Extension exercises were first advocated by Cryiax in 1969, however did not become popular in the physical therapy community until the work of Robin McKenzie in the early 1980s.11 McKenzie, a physical therapist from New Zealand brought attention to the concept of extension exercise and contended that low back pain was primarily mechanical in nature.28 He believed that this low back pain was caused by either a deformation of soft tissue due to increased stress or that there was an alteration of the position of the nucleous pulposis in the intervertebral disc.24 Mckenzie divided back pain into three different syndromes: postural, dysfunction and derangement. Postural syndrome, according to Mckenzie, was abnormal forces placed on normal structures.8 This occurred during prolonged sitting with a flexed or forward position of the upper trunk, a position he reported to be common in everyday lifestyles.24,29 This prolonged flexion placed stress on the vertebral discs and posterior elements causing the
ligaments, fascia and muscles of the low back to be elongated making them more prone to strain and irritation. 8, 29 Trauma only threatens at this point and full painfree range of motion is still intact. 10

Dysfunction syndrome was also caused by abnormal stresses on normal tissue. This abnormal stress, however, was caused by a previous injury in which soft tissue had scarred in a shortened position due to the individual's altered posture. 8 This syndrome is characterized by its chronicity (greater than three months) and manifests intermittent pain at endrange. A loss of lumbar range of motion is also noted, usually hindering extension. 10

Derangement syndrome resulted from migration of the nucleus pulposus within the intervertebral disc. (Figure 2) This migration, usually posterior, caused decreased motion in the intervertebral segment effected and decreased extension in the lumbar spine. 8 The nuclear bulge, due to the increased external forces, caused mechanical irritation of the nociceptors in the posterior longitudinal ligament, the outer fibers of the annulus fibrosus and the ventral aspect of the dura mater leading to low back pain. 8, 29 The individual with derangement syndrome shifts away from the fluid of the nucleus pulposis (the painful side). 8

Mckenzie was not alone in his theory, which related low back pain with decreased lordosis. Cyriax also agreed that lumbar lordosis protected the posterior longitudinal ligament from strain and placed an anterior pressure on the intervertebral disc. He believed that low back pain was caused by the discs exerting pressure on pain sensitive structures. 27
Figure 2. Forward Flexion (top). Extension (bottom).
Nachemson,\textsuperscript{30} examined disc pressure during different positions of the body. He concluded that within the limits of his investigation, the greater the lordosis, the less pressure on the disc.\textsuperscript{8}

Mckenzie came up with treatments for all three of his syndromes. For postural syndrome and dysfunction, he opted to counteract the negative effects of prolonged or excessive flexion. He developed a program consisting of mostly extension exercise which were passive in order to counteract the abdominal forces on the lumbar spine.\textsuperscript{29} The goals of these exercises were to maintain proper lordotic posture and to correct a dysfunction by stretching any shortened periarticular structures.\textsuperscript{27}

For the treatment of derangement, Mckenzie chose exercise that would centralize the pain.\textsuperscript{31,4} He concluded that if prolonged spinal flexion was the movement that caused the pain, prolonged or repeated extension would reduce the derangement.\textsuperscript{23} The goal of these exercises were to shift nuclear material away from the bulging annulus.\textsuperscript{28}

Basic extension exercises can be performed without special equipment. They usually include back extension in a neutral position to improve endurance or strength or back extension in a hyperextended position to promote movement of the nuclear material and increased mobility. A back extension program will also include prevention measures to avoid excessive loading of the discs in the future.\textsuperscript{32}

Overall, those who endorse spinal extension exercise will advocate using the lordotic posture to protect the spine. They will have goals that include maintaining or regaining the natural lumbar lordosis and decreasing the force on the posterior aspects and soft tissues of the spine.
Extension exercises, made well known by Mckenzie and flexion exercises advocated by Williams, both seem to be sensible and appropriate treatment for low back pain when examining the theories behind them. Research has been done to assist clinicians in developing the very best and most efficient treatments for low back pain.
Discussion of Flexion and Extension Exercises

Many studies have been performed comparing the results of spinal flexion exercise and spinal extension exercises. It would seem that when looking at the literature comparing the results of spinal flexion and extension exercises for chronic low back pain, that the results are just as varied as the two exercises themselves.

The studies supporting flexion exercises for the treatment of back pain, include three reasons. The first reason is that the lordotic posture puts pressure on the posterior portion of the disc and causes degeneration. Spinal flexion exercises decrease this lordosis, thus decreasing the stress and resulting degeneration occurring on the posterior portion of the disc. The second reason for the use of spinal extension exercises are that with the increased strength of the abdominal muscles, the pressure on the disc will be reduced due to the increased intraabdominal pressure. The third reason for using spinal flexion exercises to decrease low back pain is, because flexion exercises will give you the most flexibility in the lumbar spine, thus decreasing pain.

The studies supporting the theory of disc degeneration and back pain due to the lordotic posture includes a study by Fahri written in 1975. He looked at the relationship between posture and disc degeneration causing back pain in a jungle population in India. He noted that these people knew nothing about posture principles and tended to have a more flexed posture than that of Europe and America. Of those people in the Jungle of India, he stated, they had a zero incidence of back pain. In his
study, he x-rayed the lumbar spine of 450 of these people between the ages of 15 and 44 and read the x-rays for disc narrowing. The x-rays from the individuals in India showed an incidence of narrowing of only nine percent. This was compared to x-rays taken from heavy laborers in Sweden who showed disk narrowing of 80 percent and to office personnel in San Francisco who showed an incidence of disc narrowing to be at 35 percent. Both the workers from Sweden and San Francisco were under the age of 56 years old.

Another theory supporting the use of flexion exercises is, that with increased strength of the abdominals, there will be increased intraabdominal pressure decreasing the load on the intervertebral disc. Morris\(^3\) performed a study in 1961 in which he examined the role of the trunk muscles in reducing the load of the lumbar spine. He concluded that the force on the spine while lifting is much less, about 30\% less, when it is supported by an increased intracavity pressure. He stated that when a load is placed on the spine, the trunk muscles act to stabilize the rib cage and restrain or compress the abdominal contents. This in turn, according to Morris, causes the intracavity pressure to increase and decrease the load on the spine.

The study by Morris consisted of 10 healthy males. He measured their intraabdominal pressure and the activity of their intercostals, abdominal obliques, rectus abdominus and the deep muscles of the back while they performed different activities causing loading of their trunk. It was shown that as the subjects lifted heavier weights, the intraabdominal pressure rose also. This continued until the weights reached 150 to 200 lbs. when the amount of increase of the intraabdominal pressure decreased. The activity of the rectus abdominus was noted to be less than that of the obliques or
transversus during the activity. Morris concluded by this study that the increased abdominal pressure plays a major role in decreasing the load on the lumbar spine.

The last theory mentioned here to support spinal flexion exercises in decreasing low back pain was due to the increased flexibility that occurs during performance of these exercises. Elnaggar\textsuperscript{25} studied the effects of spinal flexion and spinal extension exercises on 56 subjects. Thoracolumbar spinal mobility in patients with chronic mechanical low back pain was measured. These patients, between ages 20 – 50 years, had experienced low back pain for three months or greater. The patients were randomly divided into two groups: a spinal extension group, which contained fifteen males and thirteen females and a spinal flexion group containing thirteen males and fifteen females. These groups both performed their respective exercises for a period of 2 weeks with each exercise session lasting 30 minutes. Spinal mobility was measured both before treatment and after treatment with measurements in three planes: sagittal, coronal, and transverse. Elnaggar concluded that spinal mobility in the transverse and coronal planes were not significantly increased in either group. Movement in the sagittal plane, however was increased significantly in the group performing flexion exercises and remained unchanged in the group performing extension exercises.\textsuperscript{23}

Extension exercises also have studies supporting their use. One of the theories given to advocate the use of extension exercises are that the increased flexed posture causes shortened tissues and movement of the nucleus pulposus posterior, placing pressure on the posterior soft tissues. The other two theories are; that extension exercises will strengthen the trunk extensors, which are weakened with low back pain causing
reoccurrence and that they will increase the flexibility of the lumbar spine more than flexion exercises.

The first theory, that a continually flexed posture contributes to low back pain and posterior movement of the disk, is found in many studies. One of the studies by Ponte,\textsuperscript{24} compared the treatment of subjects with low back pain who were placed in either a McKenzie extension group or a Williams flexion group. It included 22 subjects in the group with a history of low back pain. This history of low back pain was not to be serious or to have happened within six months prior to the present attack. Ten patients were placed in the Williams group and twelve in the McKenzie group. The patients in the McKenzie group needed only ten treatments while those in the Williams group needed twelve. At the end of their treatments 67 percent of the McKenzie group stated they had no pain while ten percent of the Williams group could state that they had no pain. When the two groups were asked if they could sit up for two hours, one hundred percent of the McKenzie group stated that they could and 30 percent of the Williams groups also answered in the affirmative.\textsuperscript{2}

Another theory that supports the use of extension exercises for low back pain is that weakness and atrophy of trunk extensors cause this pain and contributes to continued reoccurrance of low back pain.\textsuperscript{35}

Hides,\textsuperscript{36} examined the role of trunk musculature in predicting continuing problems with back pain. His study consisted of 41 patients, men and women between the ages of 18-45 years, who were experiencing their first episode of low back pain. For each subject, the duration of back pain was less than three months. The patients were
then randomly assigned into one of two groups: medical management of low back pain versus medical management along with specific exercise therapy to target the multifidus.

Diminished asymmetrical muscle size was noted in one vertebral level and occurred in all but one patient who had diminished muscle size bilaterally. In all cases the side with the diminished muscle size was the side of the subjects pain. It was concluded that muscle recovery after an episode of acute back pain does not return automatically.

The last theory here that advocates the use of extension exercises over flexion exercises is, that an individual will gain increased range of motion thus decreasing low back pain.

Again Ponte's\textsuperscript{15} study supported the effectiveness of extensor exercises. The 22 subjects, ten performing primarily flexion exercises and twelve performing extensor exercises were evaluated following the treatment. Spinal forward flexion and lateral flexion were measured along with subjective pain measurements. Not only did the McKenzie group report significantly less pain, but they also showed a significant increase in pain free range of motion in all the planes measured.

These studies supporting flexion or extension exercises are often not supported by previous or later studies. This may be due to error or perhaps the difficulty and complexity of studying the back itself. The relationship that lumbar posture has with decreasing low back pain can have conflicting results as mentioned before.

The theory that strengthening the abdominals will decrease the lumbar lordosis has been disputed. In a study by Walker,\textsuperscript{37} consisting of 31 healthy subjects, 23 women and eight men between the ages of 20 and 33 years was performed. Measurements of the
pelvic tilt and lumbar lordosis were taken before contractions of the abdominal musculature. The subject then performed a leg-lowering test in supine using the abdominal musculature and another measurement of lumbar lordosis and pelvic tilt was performed. There was found to be no significant correlation between abdominal function, pelvic tilt and lumbar lordosis.

The theory that extensor strength is most important in the reduction of low back pain has also been disputed. Hodges,26 in a study in 1996, stated that recent evidence has suggested the transverse abdominis may be critically involved when contributing to the protection and stabilization of the lumbar spine. He went on to perform a study in which 30 subjects participated. Fifteen of the patients, eight males and seven females had a history of low back pain with an insidious onset of eighteen months or less. In order to be included in this study, their back pain had to have restricted their activity, causing them to be absent at least three days from work in the last year. Also, at the time of testing, the subjects were to be experiencing only minimal pain.

The other fifteen subjects were a control group that contained matched samples of the previous group, however, with no history of low back pain. Both groups performed specific arm movements, which included rapid flexion of the shoulder. The group without low back pain always showed movement of the transverse abdominus first in order to stabilize the trunk before the action of the prime mover. The group with low back pain consistently moved the prime mover before stabilization of the trunk by the transverses abdominus. This study was done to give credence to the hypothesis that the contraction of the transverse abdominus stabilizes the trunk thus decreasing low back pain. The study supported this theory.
The theory that increased flexibility decreases lumbar pain has also been disputed. Dettore\textsuperscript{14} studied the effects of spinal flexion and extension exercises and postures in subjects who experienced acute low back pain were compared. His results came from a group of 149 subjects, 120 men and 29 women. An initial evaluation was performed on these subjects and they were randomly assigned to two groups (flexion and extension) and were later divided into five subgroups: flexion-flexion, flexion-extension, extension-extension, extension-flexion or a control group.

During the first two weeks, the flexion group, which consisted of flexion-flexion and flexion-extension exercises, received the same treatments, which included: pelvic tilt, partial sit-ups, and double knee to chest. The extension group, consisting of extension-extension and extension flexion, also performed the same exercises, consisting of extension exercises only for the first two weeks. These consisted of laying prone for 20 minutes with up to three pillows placed under the chest, one being placed every five minutes, twenty press-up exercises in the prone position were also performed. Both groups also had a ice pack placed over their lumbar spine for 20 minutes within the treatment time. The control group had no exercises or postural instructions prescribed, however, did lay prone with an ice pack over their lumbar spine for 20 minutes. In addition, one half of the flexion and one half on the extension group were given added exercises after two weeks, to perform alongside their already prescribed treatment program. These new exercises given were opposite of what they had already been doing. An evaluation was performed every week for the first eight weeks. When compared to the control group after four weeks, the subjects given the flexion exercises displayed significantly less trunk extension. No difference was noted in trunk flexion. It was
found that the subjects in the control group had the largest increase in trunk flexion and extension. It is interesting to note this because, though the study showed mixed results in range of motion increases, there was no significant difference in mean pain scores between the groups. ¹⁴

Along with the theories of flexion and extension exercises to treat low back pain, there is another theory that has come up in the literature that takes into account both the abdominal and posterior trunk musculature. This theory, one of stabilization, states that because a gradual deconditioning of the lumbar spine happens with decreased activity, all the muscles around the spine must be strengthened. ¹³

Stabilization exercises can be somewhat compared to a postural control program. The exercises prescribed, co-contract the muscles of both the flexor and extensor groups of the spine are done in order to give stability to the spinal segment. The goal of spinal stabilization exercises is to achieve a neutral spine and maintain that neutral spine during dynamic activities. Either an excessive lordotic or flattened position of the lumbar spine is not encouraged. Stabilization exercises are used for acute, chronic and recurrent low back pain. ¹³
Conclusion

Treatment programs for low back pain have been varied in the past. The results of studies have been contradictory with some advocating flexion exercise and some advocating extension. Other studies have been nonconclusive or even may have advocated that both types of exercise are just as important, such as lumbar stabilization exercises.

Perhaps these contradictory results may be due to limiting factors of a study such as nonrandom allocation of subjects, lack of functional outcome measures, low power to detect differences between groups, no control group and nonblinding of evaluators. These conflicting results may also be due to the difficulty in classifying low back pain. What may be beneficial for one patient with chronic low back pain may not work for another due to a different diagnosis, though those patients may be lumped together because of similar symptoms.

Last, but not least, is the difficulty of researching such a complex part of the body. Research methodologies that are used in the extremities may not be applicable to the trunk. The trunk may need to be looked at as its own entity.

These studies, though, it seems many may be conflicting or inconclusive, have not been for naught. Back in the early 1900’s Sir William Gowers suggested that increased perspiration caused by active exercise could be helpful in the treatment of lumbago and muscular rheumatism. We have increased our knowledge much when looking at the
relationship between exercise and low back pain since that time. We now know that exercise is beneficial and is a standard for treatment in low back pain\textsuperscript{28} and are aware of some of the specific indications for types of treatments.\textsuperscript{12} Flexion exercises have been shown to be especially beneficial for those with lumbar spondylolisthesis while extension exercises are better indicated in postmenopausal osteoporosis.\textsuperscript{39,40} The general conclusion on the most efficacious treatment however remains uncertain and will require continuing research to reach an answer.\textsuperscript{41}

As we will be sure to continue to treat low back pain in the future, it will be important to not focus on only one treatment due to our preference. Using resources available, such as the Guide to Physical Therapy Practice, we will be assisted in looking at impairments and disabilities caused by low back pain and our treatment methods challenged. Our treatments should focus on obtaining the highest function for our patients.

It is likely that much literature will continue to be available concerning low back pain. We will need to continue to look at the upcoming research, keeping our eyes open, and finding the best way to treat every individual patient with low back pain.
REFERENCES


