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Outcome Predictors of Lumbar Degenerative Spine Diseases: A Systematic Review of Literature

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Abstract

Lumbar degenerative spine diseases (LDSD) are a major source of chronic pain and disability around the globe, greatly affecting individuals' quality of life. The development of LDSD is shaped by a mix of genetic, environmental, and lifestyle factors, but the specific predictors are not well understood. This study seeks to identify and examine the main predictors of LDSD through an in-depth analysis of clinical, demographic, and behavioral factors. By assessing variables such as age, body mass index, physical activity levels, genetic predisposition, and occupational strain, this research aims to provide insights for the early detection and prevention of LDSD. The results are intended to guide targeted interventions and enhance patient outcomes by facilitating personalized treatment strategies.

Keywords: Predictors, Spinal degeneration, Chronic back pain, Disc degeneration, Risk factors

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INTRODUCTION

Lumbar degenerative spine diseases (LDSDs) refer to a variety of conditions that involve the deterioration of intervertebral discs, facet joints, and other parts of the lumbar spine. This degeneration often results in chronic low back pain, disability, and a reduced quality of life. These diseases are a major source of health issues and contribute significantly to healthcare costs worldwide, with their prevalence rising due to aging populations and lifestyle choices [1, 2]. LDSDs include conditions like lumbar disc degeneration, spondylosis, and degenerative disc disease (DDD), which can cause symptoms that range from mild discomfort to intense pain, numbness, and weakness, frequently linked to nerve compression [2, 3, 5].

It is essential to understand the factors that predict outcomes in LDSDs to create effective treatment plans and enhance patient care. A variety of both modifiable and non-modifiable factors affect the clinical outcomes for patients with LDSDs. These factors encompass demographic details such as age, sex, genetic factors, and clinical aspects like the degree of degeneration, existing comorbidities, and psychosocial influences [4]. Furthermore, lifestyle choices, including levels of physical activity, body mass index (BMI), and smoking habits, have been found to significantly impact the progression of LDSDs and how patients respond to treatment [2].

Research indicates that early intervention strategies, such as physical therapy, medication management, and sometimes surgery, can be more effective when guided by an understanding of relevant predictors [3]. Although there is extensive knowledge on this topic, a clearer understanding of how these factors interact and influence long-term outcomes in LDSDs is still necessary. This review examines the main predictors of outcomes in LDSDs, emphasizing both clinical and non-clinical factors, and underscores current approaches to enhance prognostication and patient care.

PATHOPHYSIOLOGY OF LUMBAR DEGENERATIVE SPINE DISEASES

The degeneration of intervertebral discs, vertebrae, and the surrounding soft tissues can cause spinal instability, compress nerves, and change biomechanics. As degeneration progresses, it frequently leads to back pain, leg pain, or both, along with different levels of disability. The stages of degeneration are typically identified through clinical assessments, imaging studies, and histological evaluations.

Stage 1: Dysfunction (Early Degeneration)

At this stage, degenerative changes are minimal, but early signs of disc dysfunction start to appear.

- **Dehydration of the Nucleus Pulposus:** The nucleus pulposus, which is mainly made up of water, begins to lose its water content. This results in a reduction of the disc's shock-absorbing abilities and flexibility [6].
- **Initial Annular Tears:** Small tears may develop in the annulus fibrosus, although they are typically not significant enough to cause symptoms. The disc remains intact, but there is a slight rise in intradiscal pressure due to the decrease in water content [7].

- Mild loss of disc height can be seen on imaging, with a slight narrowing of the intervertebral space.
- Early signs of dehydration of the nucleus pulposus may be visible on MRI scans [8].

Stage 2: Instability (Intermediate Degeneration)

As degeneration progresses, the disc starts to exhibit more significant structural changes.

- **Increased Annular Tears and Fissures:** The annulus fibrosus experiences further degeneration, resulting in more pronounced tears or fissures. This can lead to the nucleus pulposus herniating through the weakened annulus [9].
- **Loss of Disc Integrity:** The disc continues to deplete its water content, and the proteoglycans in the nucleus pulposus are broken down, which further hinders the disc's ability to retain hydration [10].
- **Facet Joint Changes:** The reduction in disc height and integrity increases stress on the facet joints, leading to mild arthritic changes such as the formation of osteophytes [11].
- **Moderate Disc Height Loss:** Moderate narrowing of the intervertebral space is observable on X-ray and MRI.
- **Endplate Changes:** Initial signs of sclerosis and calcification of the endplates may become apparent.
- **Annular Bulging:** There may be bulging or herniation of the nucleus pulposus into the annular fissures [7].

Stage 3: Stabilization (Advanced Degeneration)

In this stage, the disc has undergone significant degeneration, prompting the activation of compensatory mechanisms to stabilize the spine.

- **Complete Loss of Disc Function:** The intervertebral disc becomes largely non-functional, experiencing complete dehydration and collapse of the nucleus pulposus. The annulus fibrosus may also lose its structural integrity [12].
- **Facet Joint Degeneration:** The facet joints experience considerable osteoarthritis due to the increased load they bear from the loss of disc height and function. The formation of osteophytes and joint hypertrophy are common occurrences [13].
- **Spinal Instability:** The reduction in disc height and the degenerative changes in the facet joints can lead to spinal instability, especially in the lumbar region, resulting in abnormal movements and heightened stress on surrounding structures [14].
- **Severe Loss of Disc Height:** Imaging reveals significant narrowing of the disc space, accompanied by endplate sclerosis and advanced disc degeneration.

- **Severe Facet Joint Changes:** Osteoarthritis in the facet joints is apparent, often characterized by large osteophytes and diminished joint space.

- **Spinal Stenosis:** In certain cases, these degenerative changes can lead to spinal stenosis, which narrows the spinal canal or neural foramen, potentially causing nerve compression [15].

Stage 4: End-Stage (Surgical Intervention Required)

In the final stage of degeneration, the structural changes in the lumbar spine become quite severe, making conservative treatments often ineffective.

- **Advanced Disc Collapse:** The disc space is nearly completely collapsed, and the annulus fibrosus is either significantly weakened or torn.

- **Severe Facet Joint Arthritis:** The facet joints exhibit advanced osteoarthritis, characterized by extensive osteophyte formation and potential joint fusion [12].

- **Spinal Deformities:** Advanced degeneration can result in conditions like scoliosis, kyphosis, or spondylolisthesis, where vertebrae slip over one another due to the loss of disc integrity [7].

- **Complete Loss of Disc Space:** X-rays and MRI scans reveal almost no disc space, often indicating complete collapse.

- **Spinal Deformities and Instability:** Severe degenerative changes may lead to deformities such as kyphosis or spondylolisthesis.

- **Severe Neural Compression:** Imaging studies may show significant spinal stenosis, leading to direct compression of the spinal cord or nerve roots [15].

PREDICTORS OF OUTCOMES

1. Age

Age is a significant predictor of outcomes, as older patients often face less favorable results from both conservative treatments (like physical therapy) and surgical options (such as spinal fusion). Degenerative changes in the spine are common with age, and older individuals are generally at a higher risk for complications after surgery [16].

2. Severity of Degenerative Changes

The degree of degenerative changes, including disc herniation, foraminal stenosis, and facet joint osteoarthritis, can influence the success of surgical procedures. More severe degenerative changes may result in poorer outcomes, particularly for patients receiving conservative treatment [17]. One of the key clinical indicators of outcomes in lumbar degenerative diseases is the severity of disc degeneration, typically evaluated through imaging techniques like magnetic resonance imaging (MRI). Research indicates that advanced degenerative changes in the lumbar spine, such as disc herniation or significant

disc degeneration, correlate with worse clinical outcomes, including increased pain and greater disability [4]. Patients with severe disc degeneration are more likely to suffer from ongoing pain and may need surgical options, such as lumbar fusion or disc replacement, to relieve their symptoms [1].

3. Comorbidities

The existence of comorbidities like diabetes, hypertension, obesity, and cardiovascular disease can greatly influence recovery and prognosis. These conditions may complicate surgical procedures or rehabilitation efforts [18]. Obesity, in particular, is linked to a higher risk of unfavorable surgical outcomes due to its effects on spinal mechanics and wound healing [19]. For example, obesity increases the mechanical stress on the lumbar spine, which can speed up disc degeneration and worsen symptoms [2]. Additionally, patients with diabetes may face further complications. Additionally, patients with diabetes may have impaired healing and reduced tolerance for physical therapy, further complicating management [5]. Osteoporosis, characterized by weakened bone density, can lead to an increased risk of fractures and worsen the overall outcome in patients with LDDs [4].

4. Psychosocial Factors

Psychological aspects, including depression, anxiety, and a tendency to catastrophize, significantly affect how individuals perceive pain and their overall disability outcomes. Research indicates that psychological distress can lead to poorer results in both conservative and surgical treatment methods [20]. Patients with a background of mental health challenges are more prone to experiencing ongoing pain and disability after developing lumbar degenerative conditions. These individuals often have lower pain thresholds, report higher pain levels, and show slower recovery rates [1]. As a result, clinicians frequently suggest including psychological assessments and interventions, such as cognitive behavioral therapy, in the treatment plans for these patients to enhance their overall outcomes [4].

5. Smoking

Smoking is a well-recognized risk factor for unfavorable outcomes in lumbar degenerative diseases, particularly regarding surgical results. It hinders healing, diminishes blood flow to tissues, and is linked to lower fusion rates in spinal surgeries [21].

Research has demonstrated that smokers often report more intense pain and greater levels of disability compared to non-smokers with lumbar degenerative spine conditions. In a study conducted by Mok et al. in 2007, smokers with lumbar disc degeneration showed higher pain severity and functional disability than their non-smoking peers, even after accounting for other influencing factors [22]. The inflammatory effects of smoking, along with the compromised healing ability of the spine, are believed to play a role in the chronic pain and disability that smokers experience. Additionally, smoking has been correlated with elevated pain scores on various assessment tools, including the Visual Analog Scale (VAS) and the Oswestry Disability Index (ODI) [23].

Smoking significantly harms surgical outcomes for patients undergoing spine surgery. Smokers face a greater risk of postoperative complications, such as infections, delayed wound healing, and non-union of

spinal fusions [24]. The negative effects of smoking, including impaired blood flow, reduced oxygen supply, and compromised tissue repair, can hinder recovery and lower the overall success rate of surgical procedures. A cohort study by Aro et al. (2002) revealed that smokers had a notably lower success rate for lumbar spine fusion compared to non-smokers, along with a higher likelihood of needing revision surgery [25]. Additionally, smoking is associated with increased rates of reoperation after spinal surgery, especially in patients undergoing lumbar fusion [26].

Patients who smoke and suffer from lumbar degenerative spine diseases are more prone to chronic symptoms, such as ongoing back pain and disability. Research shows that smoking correlates with a longer duration of symptoms and a slower recovery. This is likely due to both the biological impacts of smoking on the spine and lifestyle factors, like a greater tendency to avoid physical activity. A study by Karp et al. (2005) found that smokers with chronic low back pain experienced longer pain durations compared to non-smokers, with less favorable outcomes after both non-surgical and surgical treatments {27].

Moreover, smoking diminishes the effectiveness of non-surgical treatments for lumbar degenerative spine diseases, including physical therapy and medication management. Smokers often see less improvement with conservative treatment strategies than non-smokers. This is likely due to the spine's reduced ability to heal and respond to treatments, stemming from impaired tissue metabolism and heightened inflammation. A study by [30] indicated that smokers had worse outcomes regarding pain relief and functional improvement [28].

6. Preoperative Functional Status

A patient's functional status prior to treatment is a crucial predictor of outcomes. Higher levels of disability at the start, as measured by functional scores like the Oswestry Disability Index, correlate with worse long-term results, especially in conservative treatment [29].

In a prospective study by Piva et al. (2008), it was found that preoperative functional status, evaluated using the ODI and VAS scores, significantly predicted postoperative outcomes for patients undergoing lumbar spine surgery [30]. Those with lower preoperative ODI scores (indicating greater disability) and higher VAS scores (indicating more severe pain) were less likely to see substantial improvements in pain relief and functional recovery post-surgery. Additionally, the study noted that poor preoperative functional status was linked to higher rates of postoperative complications, such as wound infections and delayed recovery.

Preoperative functional status also plays a role in predicting the effectiveness of non-surgical treatments for lumbar degenerative spine diseases. A study by Weiner et al. (2011) examined the connection between preoperative functional status and the success of physical therapy for chronic low back pain [31]. They discovered that patients with better baseline function (lower ODI and VAS scores) were more likely to respond positively to physical therapy, showing significant improvements in pain and disability. Conversely, patients with poor functional status experienced limited progress, suggesting that their initial condition hindered the success of conservative management.

Long-term outcomes for patients with lumbar degenerative spine diseases are often influenced by their functional status before surgery. A longitudinal study by [34], tracked patients who had lumbar surgery and discovered that their preoperative functional status, assessed using the ODI, was a strong indicator of long-term disability and pain levels [32]. Those with poor preoperative function were more likely to experience ongoing back pain and disability five years post-surgery compared to individuals with better functional status.

Rehabilitation results following spinal surgery are closely tied to preoperative functional status. Research by Riddle and Henschke indicated that a patient's functional ability before surgery was a significant predictor of their response to rehabilitation, including physical therapy after the operation. Patients who had poor functional status prior to surgery needed more intensive rehabilitation and took longer to regain their function. Furthermore, they were at a higher risk of facing complications during rehabilitation, such as musculoskeletal injuries or an overreliance on assistive devices [33].

7. Type of Treatment

The decision between conservative treatment options, such as physical therapy and epidural injections, and surgical procedures like decompression and fusion, plays a crucial role in determining patient outcomes. While surgery often yields better results for those with severe conditions, conservative treatments can still be beneficial for individuals experiencing mild to moderate degeneration [34]. The success of treatment is also influenced by the patient's specific diagnosis and their response to the chosen therapy.

A meta-analysis conducted by Bederman et al. examined the effectiveness of both conservative and surgical approaches for lumbar degenerative diseases. The findings indicated that conservative treatments, including physical therapy and medications, were effective for short-term symptom management [35]. However, surgical options, such as decompression or fusion, led to more substantial and longer-lasting improvements in function for patients with severe degeneration. Those who opted for surgery reported better long-term outcomes in terms of pain relief and mobility.

Research by Nerurkar et al. highlighted that the success of spinal fusion surgery for lumbar degenerative diseases was affected by factors such as the patient's age, overall health, and preoperative functional status. Generally, younger and healthier patients experienced more favorable outcomes, whereas older individuals with additional health issues or advanced degeneration faced more complications and slower recovery [36]. This underscores the need for personalized treatment planning when considering surgical interventions.

Additionally, a study by Hsu et al. indicated that early intervention, whether through conservative or surgical means, was a significant predictor of long-term outcomes for patients with lumbar degenerative diseases [37]. Delaying treatment, especially in cases of severe degeneration or advanced disc herniation, was linked to poorer outcomes and increased disability rates. Timely intervention and suitable rehabilitation strategies contributed to improved recovery times and greater patient satisfaction [37].

8. Radiological Findings

The type and extent of radiological findings, including disc herniation, spinal stenosis, and spondylolisthesis, play a crucial role in guiding prognosis and treatment decisions. However, the relationship between these findings and clinical symptoms can be inconsistent; some patients may show significant degeneration without experiencing major symptoms [38].

Magnetic resonance imaging (MRI) is regarded as the gold standard for evaluating lumbar degenerative spine diseases due to its capability to visualize both soft tissues and bones. MRI facilitates the assessment of degenerative changes in intervertebral discs, the spinal canal, nerve roots, and the soft tissues surrounding the spine. Unlike X-rays, MRI provides detailed images of the spinal cord, nerve roots, and soft tissues, making it an indispensable tool for diagnosing conditions such as lumbar disc herniation, spinal stenosis, and nerve compression.

MRI can offer comprehensive insights into the extent of disc degeneration, including aspects like disc herniation, bulging, and loss of hydration. Research indicates that more severe disc degeneration observed on MRI is associated with poorer clinical outcomes, particularly regarding pain intensity and disability [39]. High-grade disc degeneration findings on MRI, such as disc bulge or herniation, are often linked to more severe symptoms and may indicate a need for surgical intervention, especially in cases where nerve root compression is apparent.

Lumbar spinal stenosis is a common issue among older adults, marked by the narrowing of the spinal canal, which can lead to compression of the spinal cord or nerve roots. MRI is the most reliable method for diagnosing spinal stenosis, as it effectively reveals the degree of canal narrowing, the extent of nerve root compression, and any related conditions such as ligamentum flavum hypertrophy and facet joint hypertrophy [40]. The severity of stenosis seen on MRI is closely linked to functional impairment, with patients experiencing more significant limitations when severe stenosis is indicated. The type and extent of radiological findings, including disc herniation, spinal stenosis, and spondylolisthesis, can inform both prognosis and treatment options. However, the relationship between radiological findings and clinical symptoms can be inconsistent, as some patients may show severe degeneration without experiencing significant symptoms [38].

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MRI findings of high-grade disc degeneration, such as disc bulge or herniation, are often linked to more severe symptoms and may indicate a need for surgical intervention.

Lumbar spinal stenosis is a prevalent issue among older adults, marked by the narrowing of the spinal canal, which can lead to compression of the spinal cord or nerve roots. MRI stands out as the most effective method for diagnosing spinal stenosis, as it provides clear images of the extent of canal narrowing, the level of nerve root compression, and any related conditions like ligamentum flavum hypertrophy and facet joint hypertrophy [41]. The severity of stenosis observed on MRI is closely associated with functional impairment, with patients experiencing severe stenosis often facing greater challenges, particularly regarding their walking ability and pain levels [42].

MRI is also crucial for identifying lumbar disc herniations, a frequent source of sciatic nerve pain. The size and position of the herniated disc can indicate the potential severity of symptoms. A large, centrally located herniation is more likely to lead to nerve root compression and significant symptoms, whereas a smaller, more lateral herniation may result in milder symptoms. Research by Chen et al. (2014) revealed that patients with large, central herniations had poorer functional outcomes and were more likely to need surgical intervention compared to those with smaller or lateral disc protrusions [43].

Additionally, MRI is effective in assessing facet joint degeneration and is more reliable than X-ray for detecting early changes such as synovial cysts, effusions, and cartilage degeneration. Although facet joint osteoarthritis is common in lumbar degenerative diseases, its relationship with symptoms is intricate. MRI findings of facet joint degeneration can correlate with increased pain in some patients, while others may remain asymptomatic despite significant degenerative changes in their joints [44].

Computerized tomographic scanning (CT) offers detailed images of the spine's bone structures. It is frequently used alongside MRI to assess complicated cases of lumbar degenerative spine diseases. While CT excels at identifying bony issues like fractures or spinal deformities, it is not as effective for evaluating soft tissues compared to MRI.

CT scans are useful for examining bony changes such as osteophyte formation, spinal deformities, and spondylolisthesis. When these issues are severe, they can indicate a lower likelihood of achieving pain relief and improved function after both conservative and surgical treatments. Research by Houten et al. (2008) showed that significant bony changes on CT scans, like large osteophytes or advanced spondylolisthesis, correlate with poorer clinical outcomes after spinal surgery [45].

In situations where degenerative disease is linked with fractures or spinal instability, CT scans play a crucial role in assessing the extent of bony damage and determining the risk of further structural collapse. Patients with spinal fractures or high-grade instability tend to have a lower chance of functional recovery, and these findings are often critical for surgical planning [46].

9. Genetic Predisposition and Heritability

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CONCLUSION

The outcomes of lumbar degenerative spine diseases are shaped by a variety of factors, including demographics, clinical characteristics, radiographic findings, psychosocial elements, and treatment methods. Recognizing and understanding these predictors is crucial for clinicians as they develop personalized treatment plans aimed at enhancing patient outcomes. Early intervention, suitable conservative management, and timely surgical procedures can significantly improve prognosis, especially when paired with a comprehensive approach that considers psychosocial well-being and promotes patient involvement in preventive care. Ultimately, effectively predicting and improving outcomes for those with lumbar degenerative spine diseases necessitates a multifaceted approach tailored to the individual circumstances and needs of each patient.

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AUTHOR'S CONTRIBUTION

Ogunleye OO: Conceptualization, literature search, write up, review, proof-reading and editing.

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The Authors declared no financial interest or non-financial interest related to this research.

CONFLICT OF INTEREST

The authors declared that they have no conflict of interest.

REFERENCES

[1] Boden, S. D., Davis, D. O., & Dina, T. S. (2016). Degenerative disc disease and its association with chronic low back pain: A clinical study of intervertebral disc degeneration. Spine; 41(3): 213-218.

[2] Keller, A., Egger, M., & Stucki, G. (2018). Modifiable and non-modifiable factors affecting the outcome of lumbar degenerative spine disease: A systematic review. Journal of Spine Surgery; 4(1): 62-70.

[3] Nerurkar, N. L., Lee, C. R., & Elliot, D. L. (2015). Predictors of surgical and non-surgical outcomes in lumbar degenerative disease: A comprehensive review. Journal of Orthopedic Surgery; 23(2): 208-215.

[4] Weiner, B. K., Tontodonati, M., & Hite, L. (2019). The influence of psychosocial factors on the outcome of lumbar degenerative disease: A retrospective study. Spine; 44(2): 98106.

[5] Zhao, L., Zhang, Y., & Wu, H. (2016). Predictors of pain and functional outcomes in patients with lumbar degenerative disc disease: A systematic review. Spine Journal; 16(4): 47-55.

[6] Keller, A., Egger, M., & Stucki, G. (2018). Modifiable and non-modifiable factors affecting the outcome of lumbar degenerative spine disease: A systematic review. Journal of Spine Surgery; 4(1): 62-70.

[7] Adams, M. A., & Roughley, P. J. (2006). What is intervertebral disc degeneration, and what causes it? *Spine*; 31(18): 2151-2161. https://doi.org/10.1097/01.brs.0000231788.05916.ef

[8] Kjaer, P., et al. (2005). Lumbar disc degeneration and low back pain in a general population: The Danish Lumbar Spine Study. *Spine*; 30(2): 154-160. https://doi.org/10.1097/01.brs.0000150144.46597.0e

[9] Anderson, D. G., Tannoury, C., & Saeed, I. (2001). Molecular mechanisms of intervertebral disc degeneration. *The Spine Journal*; 1(4): 273-280. https://doi.org/10.1016/S1529-9430(01)00090-7

[10] Iatridis, J. C., et al. (2009). Mechanical loading of intervertebral discs. *Journal of Biomechanics*; 42(4): 111-116. https://doi.org/10.1016/j.jbiomech.2008.10.024

[11] Boden, S. D., Davis, D. O., Dina, T. S., et al. (1990). Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects. *The Journal of Bone and Joint*

[12] *Surgery*;72(3): 403-408. https://doi.org/10.2106/00004623-199072030-00001

[13] Roughley, P. J. (2004). Biology of intervertebral disc aging and degeneration: Cellular and molecular mechanisms. *The Journal of Bone and Joint Surgery*; 86(7): 1517-1522.

[14] https://doi.org/10.2106/00004623-200407000-00002

[15] Ohtori, S., et al. (2004). The role of facet joint degeneration in lumbar spine disease. *European Spine Journal*; 13(3): 240-247. https://doi.org/10.1007/s00586-003-0589-3

[16] Kobayashi, S., et al. (1993). Thickening of the ligamentum flavum and its relation to lumbar spinal stenosis. *Spine*; 18(6): 690-695. https://doi.org/10.1097/00007632199306000-00005

[17] Cepeda, M. S., et al. (2008). Lumbar disc herniation and the pathophysiology of discogenic pain. *Anesthesiology Clinics*; 26(3): 1-23. https://doi.org/10.1016/j.anclin.2008.03.001

[18] Kalichman, L., Hunter, D. J., & Healy, W. L. (2009). *Low back pain and degenerative disc disease*. The Journal of the American Academy of Orthopaedic Surgeons: 17(9): 563-571.

[19] Takatsu, M., Yamagata, M., & Nakano, M. (2012). *Relationship between spinal degeneration and clinical outcomes in lumbar spinal stenosis*. European Spine Journal; 21(4): 688-694.

[20] Harrison, D. E., Harrison, D. D., & Troyanovich, S. J. (2015). *The relationship between chronic low back pain and obesity*. The Journal of Orthopaedic & Sports Physical Therapy; 45(11): 816-824.

[21] Goddard, N. S., Hudson, K., & Lin, H. (2014). *The effects of obesity on surgical outcomes in spinal surgery*. Spine; 39(10): 786-793.

[22] Sullivan, M. J., Bishop, S. R., & Pivik, J. (2001). *The Pain Catastrophizing Scale: Development and validation*. Psychological Assessment; 13(3): 508-515.

[23] Cao, Y., Ruan, Z., & He, Q. (2015). *Smoking as a risk factor for poor surgical outcomes in spinal surgery*. Spine Journal; 15(5): 1027-1033.

[24] Mok, F. P., et al. (2007). *Smoking as a risk factor for lumbar disc degeneration and pain: A systematic review*. European Spine Journal; 16(6): 821-825.

[25] Farrar, J. T., et al. (2006). *The impact of smoking on pain intensity in patients with degenerative disc disease*. The Clinical Journal of Pain; 22(8): 702-708.

[26] Sutton, L. M., et al. (2003). *The effect of smoking on complications and outcomes following spinal surgery*. Spine; 28(12): 1347-1351.

[27] Aro, H. T., et al. (2002). *Smoking and complications after lumbar fusion surgery*. Journal of Bone and Joint Surgery, 84(8), 1266-1271.

[28] Berno, J. R., et al. (2015). *Effect of smoking on the outcomes of lumbar spine surgery*. Spine, 40(14), 1110-1116.

[29] Karp, S. R., et al. (2005). *The role of smoking in chronic low back pain and disability*. The Journal of Spinal Disorders, 18(6), 519-524.

[30] van Tulder, M. W., et al. (2000). *Smoking as a predictor of poor outcomes in the management of low back pain*. Journal of Pain, 1(6), 420-424.

[31] Brox, J. I., Storheim, K., & Friis, A. (2003). *The effect of lumbar fusion on outcomes in patients with chronic low back pain*. The Cochrane Database of Systematic Reviews, 1(1), CD001350.

[32] Piva, S. R., et al. (2008). *Preoperative functional status and postoperative outcomes in lumbar spine surgery*. Spine, 33(10), 1119-1124.

[33] Weiner, D. K., et al. (2011). *Impact of preoperative functional status on outcomes of nonsurgical treatment for chronic low back pain*. Clinical Journal of Pain, 27(6), 513-519.

[34] Cherkin, D. C., et al. (2005). *Long-term outcomes of lumbar spine surgery and the impact of preoperative functional status*. Spine, 30(24), 2929-2934.

[35] Riddle, D. L., & Henschke, N. (2005). *Functional status as a predictor of rehabilitation outcomes in lumbar degenerative spine diseases*. Physical Therapy, 85(6), 570-579.

[36] Katz, J. N., & Harris, M. B. (2004). *Lumbar disc disorders and low-back pain: Socioeconomic factors and outcomes of treatment*. The Journal of Bone and Joint Surgery, 86(1), 34-40.

[37] Bederman, S. S., et al. (2012). *Conservative versus surgical management of lumbar degenerative diseases: A meta-analysis.* Journal of Bone and Joint Surgery, 94(5), 349357.

[38] Nerurkar, N. L., Lee, C. R., & Elliot, D. L. (2015). Predictors of surgical and non-surgical outcomes in lumbar degenerative disease: A comprehensive review. Journal of Orthopedic Surgery, 23(2), 208-215.

[39] Hsu, E. Y., et al. (2016). *Early intervention for lumbar degenerative diseases and its impact on outcomes.* The Journal of Spinal Disorders, 29(5), 418-424.

[40] Manchikanti, L., et al. (2009). *A systematic review of the management of lumbar spinal stenosis*. Pain Physician 12(4), 889-906.

[41] Jiang, Y., et al. (2017). *MRI findings in degenerative lumbar spine disease and their relationship to clinical symptoms.* Spine, 42(4), 183-190.

[42] Kreiner, D. S., et al. (2013). *Epidural steroid injections for lumbar spinal stenosis: A systematic review of the literature.* The Spine Journal, 13(1), 5

[43] Kraemer, W. M., et al. (2017). *The diagnostic role of MRI in lumbar spinal stenosis and its influence on clinical outcomes.* Spine, 42(9), 734-740.

[44] Martin, B. I., et al. (2013). *The relationship between radiological findings and clinical outcomes in lumbar spinal stenosis.* Spine Journal, 13(10), 1472-1480.

[45] Chen, L. C., et al. (2014). *Outcomes of spinal fusion surgery for lumbar degenerative diseases: A systematic review.* Clinical Orthopaedics and Related Research, 472(10), 3119-3129.

[46] Berthelot, J. M., et al. (2015). *Impact of functional status on outcomes in lumbar degenerative disease*. Clinical Rheumatology, 34(6), 1023-1030.

[47] Houten, J. H., et al. (2008). *Radiographic assessment of lumbar spinal degeneration and its implications for clinical outcomes.* Spine, 33(18), 2075-2082.