NATIONAL STUDENT RESEARCH INSTITUTION (NSRI)
Open Science • Student Research • 2026

Article Type: Review

Breaking Down While Sitting Down: A Narrative Review of the Effects of Prolonged Sitting on the Spine

Author:
Supriyaa Kannan

ORCID iD:
F. Author: https://orcid.org/0009-0000-3754-3090

Affiliation:
Eastlake High School, Sammamish, WA, USA

Manuscript Length

Review: 4,157 words

Abstract

Prolonged sitting has become increasingly common due to sedentary lifestyles, while lower back pain rates are rising. Herniated intervertebral discs are a leading cause of chronic lower back pain among adults. Although herniated discs are often associated with old age or injury, evidence suggests that extended periods of sitting and poor posture are key factors in disc degeneration. Many individuals remain unaware of this correlation, leading to delayed prevention and treatment. This review finds that prolonged sitting and improper posture are associated with increased spinal loading and internal stress within the intervertebral disc, potentially accelerating degeneration and herniation. This narrative review of primary and secondary sources found that sitting induces continuous axial compression on the spine, disrupts disc hydration, and increases stress levels within the inner layers of the disc. Primary studies revealed that individuals with low levels of physical activity showed greater risk of long-term disc degeneration. These findings highlight that maintaining proper posture, regular movement, and reducing sedentary behavior may help support long-term spinal health, though their effectiveness in preventing herniated discs has not been directly tested. This study serves as a foundation for further investigation or exploration of the long-term impact of lifestyle behaviors on spinal health and the effectiveness of preventive measures in reducing herniated disc cases.

Keywords: Intervertebral Disc Degeneration; Lumbar Disc Herniation; Sedentary Behavior; Prolonged Sitting; Sitting Posture; Spinal Loading; Lower Back Pain

1. Introduction

Approximately one in four American adults spend more than eight hours a day sitting, unaware of the consequences on their spines[1]. In a time where sedentary work has become increasingly common, musculoskeletal disorders have become both extensive and overlooked[1]. The National Health Interview Survey, conducted by the National Center for Health Statistics, is a nationwide health survey that collects data from a representative sample of U.S adults. The data from 2019 underscores the spread of musculoskeletal pain among adults in the United States. During the three months preceding the survey, 39% of adults reported having back pain, 36.5% reported having lower limb pain, and 30.7% experienced upper limb pain[2]. These statistics show a high prevalence of back pain in the United States, which is closely related to herniated intervertebral discs.

Herniated discs, commonly referred to as "slipped" or "ruptured discs," are among the most common causes of lower back pain in adults aged 30 to 50 years. To understand the nature of herniated discs, it is important to study the structure and function of the spine. The vertebral column, or spine, is composed of a series of vertebrae that protect the spinal cord while facilitating movement and flexibility. Between each vertebra is an intervertebral disc, which absorbs shock and distributes forces evenly to prevent stress on an individual region of the spine. Each disc contains two components: the annulus fibrosus, the outer ring made up of layers of collagen that provide stability, and the nucleus pulposus, the gel-like inside that provides flexibility and hydration. A herniated disc results when excessive stress creates a tear in the annulus fibrosus, causing the nucleus pulposus to leak through, compressing nearby spinal nerves. This injury most often occurs in the lumbar vertebrae region of the spinal cord, specifically between the fourth and fifth lumbar vertebrae. These lowest sections of the lumbar spine bear the vast majority of the body's weight and are uniquely vulnerable because the outer wall of the annulus fibrosus receives less structural support from the posterior longitudinal ligament. Common symptoms include pain, nerve irritation, and loss of sensation in the legs. In extreme cases, herniation may even lead to the loss of bladder and bowel control.

While herniated discs are often correlated to aging or acute injuries, evidence indicates that prolonged sitting and poor posture are contributing factors. Extended periods of sitting, improper posture, and lack of movement are associated with disc degeneration. Despite the high prevalence of back pain, many individuals remain unaware of the effects of their daily lifestyle and behaviors on their spinal health. This lack of awareness leads to delayed prevention, often addressing symptoms only after a significant amount of damage has occurred.

The spine's level of stability during standing and walking depends on its natural curves: cervical and lumbar lordosis and thoracic kyphosis. These curves work together with the intervertebral discs and surrounding muscles to distribute body weight and absorb shock during movement.[3] This architecture appears to be better suited to intermittent loading than to sustained static postures, such as sitting in a slumped position which flattens the lumbar curve and shifts a greater share of the load onto the front of the intervertebral disc. This may explain why static sitting interacts differently with the spine than standing or walking do.

It is critical to differentiate prolonged sitting time from related factors such as overall physical activity level, occupation type, and pre-existing spinal conditions, each of which may influence spinal health.

The rationale for this study is to educate individuals about the correlation between daily activities and overall spinal health. While many people undergo treatment after diagnosis, little is done to ensure understanding of how daily activities can affect spine health. This often leaves individuals in a constant cycle of pain management and alters their lifestyle drastically.

This study is significant because it addresses the root cause of a condition that affects millions of adults in the United States and worldwide. By emphasizing the impact of daily lifestyle behaviors on spinal health, this study aims to increase

awareness of prevention methods for reducing the risk of spinal disc damage. If a majority of the population becomes aware of this connection, a substantial number of cases regarding herniated discs may be prevented by undertaking preventive measures, although this has not been directly studied. Since herniated discs can cause both short- and long-term physical challenges, injury prevention has the potential to make an adult's life more sustainable

2. Methods

This is a narrative non-systematic review: no systematic review protocol was registered, and no formal risk-of-bias or quality-appraisal tool was applied to the screened sources.

The primary objective of this study was to investigate the relationship between prolonged sitting and the development of herniated discs, in addition to exploring prospective spinal injury prevention methods. Literature was primarily sourced from PubMed, Google Scholar, and official health organization databases including the Centers for Disease Control and Prevention and World Health Organization. These sources were selected based on several factors including their credibility, peer-reviewed content, and range of clinical research. Searches were conducted between July 2025 and November 2025. Search terms included “herniated disc anatomy,” “lumbar disc degeneration,” “clinical results of prolonged sitting,” “spinal disc clinical trials,” “herniated disc prevention,” and “herniated disc interventions.” Additional searches included targeted reviews and analysis on risk factors, levels of symptoms, and treatment results. Searches were also used to further understand foundational terminology and anatomical structures, including terms such as “vertebral anatomy,” “intervertebral disc structure,” and “spinal column overview,” to develop the background knowledge necessary for interpreting complex clinical studies and results. Studies used included peer-reviewed clinical articles, reviews, literary analyses, clinical trials, and experimental research from reputable medical and public health sources. There was no date range applied for the purpose of illustrating essential anatomical research as well as recent clinical findings. However, there was a preference for studies with broad, diverse sample sizes and clear methodology. Initially, about 30–35 sources were screened across the databases listed above, out of which 20 met the above criteria for source credibility, peer-review, and range of analysis or clinical research. Of the 20 sources that met the criteria, 15 sources were used in this review. Sources that were excluded from the review either addressed topics not relevant to disc herniation or a topic covered in this review, or lacked primary data. Inclusion requirements included that sources be peer-reviewed, methodologically described, and directly address sitting, posture, sedentary behavior, or intervertebral disc pathology. Sources were excluded if they were non-peer-reviewed patient-education or commercial pages used as a primary evidentiary source, and if they lacked a described methodology. The type of research conducted is a secondary literary review based on published clinical articles, research studies, and journal articles. Numerous databases were reviewed to identify articles and studies regarding spinal anatomy, disc degeneration, risk factors, symptoms, and prevention methods. Then, analysis was used by comparing findings and conclusions from several primary studies. The focus of the analysis was to identify commonality regarding how sitting increases pressure on the spinal disc and which interventions have yielded results. No physical tools or materials were used in this study other than online sources. Biases were eliminated by employing a variety of studies and articles from around the world, ensuring various samples and perspectives.

3. Results

Spinal loading refers to the distribution of forces on the spine, specifically on the vertebrae, intervertebral discs, and ligaments. Types of forces include compression, rotation, tension, and shear, all of which affect the longevity of the

spine.[3] During normal circumstances, such as when a person is in a neutral standing position, spinal loading is distributed evenly across the spine, otherwise called a normal spinal loading pattern. This distribution is caused by the synergy of the spine's natural curves, intervertebral discs, and muscles that absorb and distribute forces evenly to avoid “point loading” on a certain part of the spine, thereby reducing the risk of tissue damage. However, sitting disturbs these natural patterns, causing an uneven distribution of forces.

This review distinguishes between four distinct, related outcomes discussed below: spinal loading (a biomechanical measure of force distribution, sometimes reported as intradiscal pressure or von Mises stress), disc degeneration (structural or biochemical changes such as dehydration or height loss), disc herniation (a specific event in which nucleus pulposus material protrudes through a tear in the annulus fibrosus), and low back pain (a symptom that can occur independently of degeneration or herniation). These terms are not used interchangeably in the sections that follow.

Author, Year	Design	Sample / Population	Exposure Measured	Outcome Measured	Evidence Strength
Nachemson & Elfström, 1970 [14]	In vivo intradiscal pressure measurement	Small healthy adult sample	Posture (standing vs. sitting variants)	Intradiscal pressure (%)	Low — small, dated sample; physiologic, not a clinical outcome
Zielinska et al., 2021 [4]	Narrative review	N/A (literature synthesis)	Sedentary behavior / sitting	Disc pathology risk factors (synthesis)	Low–moderate — narrative synthesis, not primary data
Cho et al., 2023 [5]	Finite element (computational) model	Simulated lumbar spine model; not human subjects	Sitting posture (standing, erect, slumped, floor)	Simulated von Mises stress in AF/NP	Low for clinical inference — biomechanical simulation only
Maurer et al., 2020 [6]	Longitudinal cohort, MRI-based	385 individuals, general population, 14-yr follow-up	Self-reported physical activity level (not sitting time)	MRI signs of disc degeneration	Moderate — large N, long follow-up; exposure is activity, not sitting
Qi et al., 2023 [7]	Case-control	Adolescents/adults with vs. without herniation	Sitting duration/day, posture	Diagnosed disc herniation	Moderate — retrospective; recall and reverse-causation risk
Mahdavi et al., 2021 [8]	Systematic review & meta-analysis	Multiple studies, various ages	Sedentary behavior (variably defined)	Low back pain	Moderate — aggregates observational studies; LBP is a symptom, not degeneration/herniation
Ussery et al., 2018 [1]	Cross-sectional survey analysis	US adults	Sitting time & leisure activity (joint prevalence)	Prevalence estimates only	Descriptive — establishes prevalence, not risk or causation

Table 1. *Study characteristics and evidence strength for the primary studies discussed in this review. All human studies are observational; the Cho et al. (2023) data are computational/simulated. Table generated by Claude, using information from research sources and findings.*

Table 1 illustrates the range of evidence that this review uses, from a computational finite element model (Cho et al.) and a small, decades-old physiological measurement (Nachemson & Elfström) to larger observational cohort, case-control, and meta-analytic studies. This range is important because each type of study supports a different kind of claim: the computational and physiological studies show that posture plausibly changes the mechanical load on the disc, while the cohort, case-control, and meta-analytic studies show that sitting-related behaviors are associated with degeneration, herniation, and pain in real populations. However, none of these designs can individually or collaboratively establish that prolonged sitting causes these outcomes.

1) Prolonged sitting is associated with uneven spinal loading

A secondary review by Zielinska et al. identified prolonged sedentary activities, specifically extended sitting, as a major cause of intervertebral disc herniation and degeneration[4]. According to the review, sitting induces continuous axial compression, meaning that the spine is being forcefully compressed downwards consistently. Because sitting requires

minimal spinal movement, it prevents the spine from being able to redistribute the forces. This hindrance in spinal force redistribution results in built-up pressure in the lower lumbar discs, where herniation most commonly occurs.

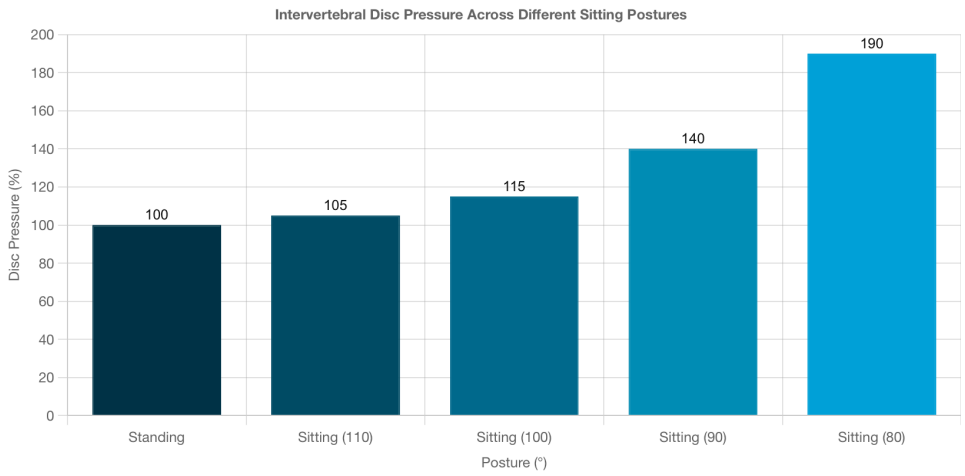

Figure 1: *Comparison of Intervertebral Disc Pressure Across Different Sitting Postures. Standing pressure is shown as the baseline (100% pressure) for comparison. As the angle of the back decreases while sitting, disc pressure increases rapidly, reaching 190% in a leaning sitting posture, demonstrating the increased compressive load placed on the intervertebral discs during prolonged sitting. Data adapted from Nachemson and Elfstrom.*[14]

2) Sustained compression is associated with disrupted disc hydration and structure

Zielinska et al. also highlight that prolonged sitting adversely affects the internal health of the nucleus pulposus and annulus fibrosus[4]. As intervertebral discs do not contain their own blood supply, they rely on movement, such as walking or running, to allow nutrients and oxygen to rediffuse into them[4]. Additionally, movement allows the spinal disc to load and unload forces, maintaining disc flexibility and strength. Prolonged sitting reduces these benefits, limiting nutrient exchange and weakening the discs. When subjected to this continuous mechanical stress, the cells responsible for maintaining disc tissue begin to deteriorate, resulting in a lowered production of molecules that facilitate the absorption and retention of water. Over time, these changes lead to disc dehydration and loss of structure, which makes the intervertebral disc increasingly susceptible to injury.

3) Biomechanical modeling suggests that improper sitting posture increases internal disc stress levels

Biomechanical research has shown that certain postures play an important role in spinal loading. A 2023 study measured von Mises stress levels, a measure of a given material's potential to yield or fracture, of the annulus fibrosus and nucleus pulposus in four positions, including standing, erect sitting in a chair, slumped sitting in a chair, and sitting on the floor. The results of the study showed that the von Mises stress levels of the annulus fibrosus and nucleus pulposus in the slumped sitting on a chair posture and sitting on the floor posture were significantly higher than the standing or erect sitting posture, being almost double the value[5]. Those values highlight that improper sitting postures nearly double the internal stress experienced by the intervertebral disc compared to standing or erect sitting, increasing the risk of structural damage and degeneration.

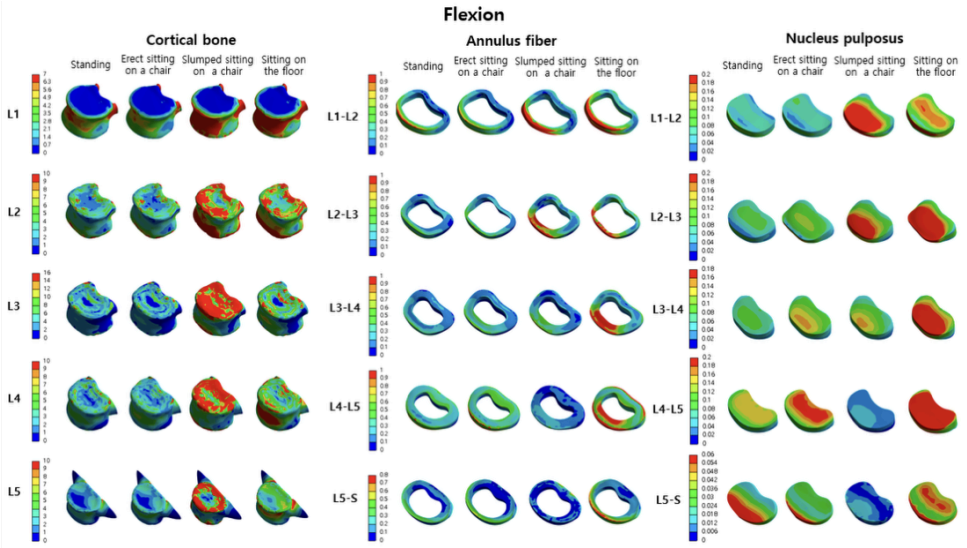

Figure 2: *von Mises Stress Level Distributions in the Cortical Bone, Annulus Fiber, and Nucleus Pulposus across four different postures (standing, erect sitting in a chair, slumped sitting in a chair, and sitting on the floor). Reproduced from Cho et al. (2023), Bioengineering, under the Creative Commons Attribution (CC BY 4.0) license.*[5]

4) Prolonged sedentary activities are associated with long-term degeneration

A 14-year MRI-based study examining intervertebral disc health in relation to levels of physical activity was conducted by Maurer et al.[6]. Using MRI scans, the research team concluded that individuals with low levels of physical activity showed signs of disc degeneration, including reduced disc height and signal changes[6]. Over the 14-year duration of the study, participants with lower physical activity showed more active degeneration than those with high levels of activity. These findings indicate that prolonged sitting and lack of activity prevent the intervertebral disc from recovering from stress, contributing to long-term degeneration.

Due to the fact that the study measured overall physical activity level rather than sitting time directly, these findings address the role of movement and activity in disc recovery rather than sitting duration specifically.

5) Extended periods of sitting and improper posture are associated with an increased risk of herniation

In 2023, Qi et al. conducted a population-based study examining lifestyle-related risk factors for disc herniation in adolescents and adults[7]. The research team compared participants diagnosed with disc herniation to an unaffected control group, studying their daily habits, including duration of sitting per day, posture, and activity levels[7]. The results showed that individuals who sat for longer than six hours a day had a significantly higher risk of disc herniation than those who sat for shorter periods. Additionally, improper posture was identified as an independent risk factor for disc herniation, meaning that regardless of the other factors, it increased the risk of injury. These results show that long periods of sitting and improper posture place stress on the lumbar region, increasing the risk of disc herniation even in young adults.

6) Structural stress from extended sitting is associated with increased lower back pain

A review conducted by Mahdavi et al. studied the relationship between sedentary behavior and lower back pain across various age groups[8]. From analyzing data from numerous studies, the research team concluded that individuals who engaged in high levels of sedentary behavior faced a greater amount of lower back pain[8]. The research team also highlighted that extended periods of sitting result in muscle stiffness, reduced spinal flexibility, and uncomfortable

movements. These results highlight that stress from sitting does not just lead to internal changes, but also functional changes, such as daily discomfort.

Due to “sedentary behavior” being defined differently across the studies examined in this review, ranging from occupational sitting to leisure screen time, it is used as a broad indicator of low-movement behavior rather than a precise measure of sitting duration.

Diagnosis of Disc Herniation

Disc herniation is commonly diagnosed through a combination of clinical history, physical examination findings such as pain caused by specific movements or a positive nerve-tension test, and magnetic resonance imaging (MRI) which allows visualization of disc position, hydration, and any compression of nearby nerve roots.[10] Due to degenerative changes being common on MRIs even in people without symptoms, a diagnosis of clinically significant herniation usually requires that imaging findings correspond to the patient's reported symptoms and exam results. This distinction matters for the studies discussed above, as an MRI-based finding of degeneration (Maurer et al.) is not equivalent to a symptomatic, clinically diagnosed herniation (Qi et al.).

Consequences on the Intervertebral Disc

Because the intervertebral disc is composed of the annulus fibrosus and nucleus pulposus, it is highly sensitive to changes in spinal loading. When spinal forces are balanced, the disc is able to absorb and redistribute external pressure. However, unbalanced spinal forces cause the disc to retain excess compression and limit its ability to redistribute pressure.

As highlighted in the studies in the section above, many factors increase stress within the annulus fibrosus and nucleus pulposus, a key factor being improper sitting postures. The excess stress increases the likelihood of structural decay within the disc, making it more vulnerable to damage. When excessive compression is applied to the disc for extended periods, small tears called microtears form in the annulus fibrosus[9]. These tears, although minuscule, weaken the outer protective ring of the disc, making it difficult to retain the inner layer.

As the annulus fibrosus weakens, pressure causes the nucleus pulposus to flow outwards through the microtears. In some cases, the gel-like substance pushes outwards and compresses nearby spinal nerves. At this stage, the injury is officially classified as a herniated intervertebral disc.

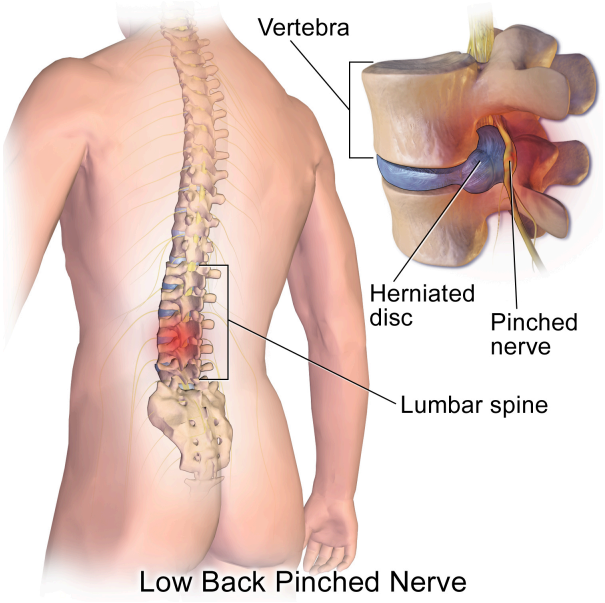

Figure 3. *Diagram of a herniated intervertebral disc and its relationship to nearby spinal nerves. The nucleus pulposus is shown protruding through a microtear in the annulus fibrosus, pinching an adjacent spinal nerve. Image reproduced from WikiJournal of Medicine.*[15]

Effects of Herniated Discs

A herniated disc can significantly affect an individual's life physically and mentally. While a small percentage of those with this condition experience no symptoms, many of those individuals must make substantial lifestyle changes. A herniated disc can cause significant pain even while doing simple tasks such as bending, walking, sitting, and twisting[10]. In extreme cases, individuals may even experience numbness or shooting pain down their arms and legs[13]. Numbness often impairs sensory motions such as gripping items or maintaining balance. These physical impairments can affect an individual's mental well-being, as pent-up frustration and discomfort can lead to anxiety or depression[12].

Prevention and Intervention

In some situations, herniated discs can heal themselves due to a process known as spontaneous resorption, where the body reabsorbs excess nucleus pulposus material and reduces symptoms[11]. Treatment for this injury is split into two categories: non-invasive and invasive. Non-invasive treatments include physical therapy, over-the-counter muscle relaxants to manage symptoms, massage therapy, epidural corticosteroid injections, and acupuncture. The leading invasive treatment is a microdiscectomy, a minimally invasive procedure where the protruding part of the disc is removed through a small incision. While there are a variety of treatments available, many of these solutions do not yield long-term results, though controlled data on these treatments remain limited, often resulting in a partially healed herniated disc or requiring ongoing treatments.

4. Discussion

The findings above indicate that prolonged sitting and improper posture are consistently associated with increased spinal loading, reduced disc hydration, and greater likelihood of degeneration, herniation, and low back pain, which directly addresses this review's objective of examining the relationship between prolonged sitting and herniated discs. However,

due to the human studies reviewed being observational and the Cho et al. findings being based on a computational model rather than clinical data, this evidence supports an association rather than a proven causation.

Prolonged sitting time is not equivalent to overall physical activity level, occupation type, or pre-existing spinal conditions. The Maurer et al. findings on physical activity and the Mahdavi et al. findings on broadly defined sedentary behavior should not be read as direct evidence about sitting duration itself, which was measured most directly by Qi et al.. Combining these related factors risks an overstatement of what any study shows about sitting specifically.

This review also has notable strengths, examining studies conducted in multiple countries by independent research groups, which reduces the likelihood that the findings reflect a single population or team's bias. It also integrates several types of evidence, computational modeling, in vivo pressure measurement, longitudinal cohort data, case-control data, and meta-analytic synthesis, that intersect a similar conclusion despite using different methods and measuring different specific outcomes. This intersection across independent methodologies strengthens the association between sitting-related behaviors and spinal health, although no single study design can establish a causation on its own.

While this review cannot establish causation, the findings summarized above provide reasonable evidence for commonly recommended practices such as taking regular movement breaks during long periods of sitting, alternating between sitting and standing throughout the day, and maintaining an upright rather than slumped seated posture. These practices are consistent with the biomechanical and observational evidence analyzed, but their effectiveness at preventing disc degeneration or herniation specifically has not been directly tested in controlled trials. Therefore, they should be presented as reasonable precautions rather than as proven interventions.

This review is limited because of the reliance on secondary papers rather than original lab data. Because no primary experiments or observations were conducted, the findings of this paper are dependent on the quality and conclusions of the sources used. While efforts were made to incorporate a wide range of studies and articles from various sources, the absence of primary data limits the ability to draw conclusions. Additionally, the studies used had several different factors, including methodology, sample size, demographics, and measurement methods, making comparison difficult. Many of the studies used also had narrow sample populations, meaning that their results may not be an accurate representation of the global adult population across different lifestyles, occupations, and body types. Furthermore, variables like obesity, genetic predisposition to spinal diseases, pre-existing conditions, and physically demanding occupations were not consistently controlled for across the reviewed studies. Future research should prioritize longitudinal studies with diverse, controlled populations to more precisely establish the relationship between sedentary behavior and intervertebral disc degeneration.

5. Conclusion

This paper highlights that prolonged sitting is associated with excessive stress on the intervertebral disc, appearing to contribute to disc degeneration and an increased risk of herniation. Additionally, von Mises stress levels highlight vulnerability to microtears in the annulus fibrosus and nucleus pulposus with increased stress levels. As these microtears progress, the nucleus pulposus can protrude outwards, compressing nearby spinal nerves, reaching the stage that officially classifies this injury as a herniated intervertebral disc. The herniated disc can have substantial, life-changing effects on an individual's physical and mental health.

Thus, prevention may be a reasonable strategy for reducing the risk of herniated discs. While there are several intervention options, including physical therapy, over-the-counter muscle relaxants to manage symptoms, massage

therapy, epidural corticosteroid injections, and acupuncture, many individuals continue to experience symptoms and need major lifestyle changes or recurring treatment.

In summary, primary and secondary studies discussed throughout this review show that improper sitting postures and extended periods of sitting are associated with significantly increased spinal loading and internal stress in the intervertebral disc. These findings align with other secondary research that has correlated sedentary behaviors to disc degradation and herniation, and highlight the need to educate the population on prevention.

Abbreviations

AF: Annulus fibrosus

NP: Nucleus pulposus

LBP: Low back pain

MRI: Magnetic resonance imaging

CDC: Centers for Disease Control and Prevention

WHO: World Health Organization

NHIS: National Health Interview Survey

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics Statement

This study did not involve human participants, private identifiable data, or animal subjects; it is a narrative review of previously published, publicly available literature and publicly available survey data (CDC National Health Interview Survey). Therefore, ethics approval was not required.

AI Use Statement

The author used Claude (Anthropic) to generate a table (based on information from the paper and cited sources) and for reviewing purposes to assist with editing. All AI-assisted content was reviewed, verified, and edited by the author, who takes full responsibility for the accuracy and integrity of the manuscript.

References

1. Ussery EN, Fulton JE, Galuska DA, Katzmarzyk PT, Carlson SA. Joint prevalence of sitting time and leisure-time physical activity among US adults, 2015–2016. JAMA. 2018;320(19):2036-2038. https://jamanetwork.com/journals/jama/fullarticle/2715582

2. Centers for Disease Control and Prevention. 2019 NHIS questionnaires, datasets, and documentation. National Health Interview Survey. 2024. https://www.cdc.gov/nchs/nhis/documentation/2019-nhis.html

3. Adams MA, Dolan P. Spine biomechanics. J Biomech. 2005;38(10):1972-1983. (replaces original non-peer-reviewed "Back Care Clinic" source)

4. Zielinska N, Podgórski M, Haładaj R, Polguj M, Olewnik Ł. Risk factors of intervertebral disc pathology—a point of view formerly and today—a review. J Clin Med. 2021;10(3):409. https://www.mdpi.com/2077-0383/10/3/409

5. Cho M, Han JS, Kang S, et al. Biomechanical effects of different sitting postures and physiologic movements on the lumbar spine: a finite element study. Bioengineering. 2023;10(9):1051. https://www.mdpi.com/2306-5354/10/9/1051

6. Maurer E, Klinger C, Lorbeer R, et al. Long-term effect of physical inactivity on thoracic and lumbar disc degeneration—an MRI-based analysis of 385 individuals from the general population. Spine J. 2020;20(9):1386-1396. https://www.sciencedirect.com/science/article/abs/pii/S1529943020301662

7. Qi L, Luo L, Meng X, Zhang J, Yu T, Nie X, Liu Q. Risk factors for lumbar disc herniation in adolescents and young adults: a case–control study. Front Surg. 2023;9:1009568. https://www.frontiersin.org/articles/10.3389/fsurg.2022.1009568/full

8. Baradaran Mahdavi S, Riahi R, Vahdatpour B, Kelishadi R. Association between sedentary behavior and low back pain; a systematic review and meta-analysis. Health Promot Perspect. 2021;11(4):393-410. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8767074/

9. Iatridis JC. Mechanisms for mechanical damage in the intervertebral disc annulus fibrosus. J Biomech. 2004;37(8):1165-1175. (replaces original non-peer-reviewed "Centers for Artificial Disc" source)

10. Amin RM, Andrade NS, Neuman BJ. Lumbar disc herniation. Curr Rev Musculoskelet Med. 2017;10(4):507-516. (replaces original non-peer-reviewed "Atlanta Spine Institute" source)

11. Zhong M, Liu JT, Jiang H, Mo W, Yu PF, Li XC, Xue RR. Incidence of spontaneous resorption of lumbar disc herniation: a meta-analysis. Pain Physician. 2017;20(1):E45-E52. (replaces original non-peer-reviewed "Cleveland Clinic" source)

12. Fernandez M, Colodro-Conde L, Hartvigsen J, Ferreira ML, Refshauge KM, Pinheiro MB, Ordoñana JR, Ferreira PH. Chronic low back pain and the risk of depression or anxiety symptoms: insights from a longitudinal twin study. Spine J. 2017;17(7):905-912. (replaces original non-peer-reviewed "Mayo Clinic" source)

13. World Health Organization. Low back pain. 2023. https://www.who.int/news-room/fact-sheets/detail/low-back-pain

14. Nachemson A, Elfström G. Intravital dynamic pressure measurements in lumbar discs: a study of common movements, maneuvers and exercises. Scand J Rehabil Med Suppl. 1970;1:1-40. https://pubmed.ncbi.nlm.nih.gov/4257209/

15. Blausen.com staff. Medical gallery of Blausen Medical 2014. WikiJournal of Medicine. 2014;1(2). https://en.wikiversity.org/wiki/WikiJournal_of_Medicine/Medical_gallery_of_Blausen_Medical_2014