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The Association Between Physical Activity and The Development of Degenerative Spine Disease: A Review

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ABSTRACT

Introduction: Degenerative spine disease (DSD) encompasses conditions such as intervertebral disc degeneration, spinal stenosis, and spondylosis, often linked to aging and lifestyle factors. Physical activity is frequently proposed as a modifiable factor influencing the onset and progression of DSD. This review explores the relationship between physical activity and DSD development, highlighting its potential role in prevention and management.

Materials and Methods: A comprehensive literature review was conducted using PubMed, Scopus, and Web of Science databases, focusing on studies published between 2000 and 2024. Keywords included "degenerative spine disease," "physical activity," "exercise," and "spinal health." Inclusion criteria comprised observational studies, clinical trials, and meta-analyses that examined physical activity's effects on DSD risk or progression.

Results: Findings suggest a dual role of physical activity in DSD development. Moderate, consistent exercise, particularly low-impact activities like swimming, yoga, and walking, appears protective, enhancing spinal muscle strength, flexibility, and disc nutrition. Conversely, high-intensity or repetitive loading activities, such as heavy lifting or contact sports, are associated with an elevated risk of accelerated degeneration. Evidence highlights a dose-dependent relationship, where activity type, intensity, and duration critically modulate outcomes. Limited studies suggest potential genetic and biomechanical factors influencing individual responses to physical activity.

Conclusions: Physical activity exerts a complex influence on DSD development, with moderate exercise showing potential benefits while excessive strain may increase risks. Tailored exercise regimens could mitigate DSD progression, emphasizing the importance of personalized physical activity guidelines. Further longitudinal studies are needed to clarify mechanisms and optimize prevention strategies.

Keywords: degenerative spine disease, spinal health, lower back pain, physical activity

INTRODUCTION

Degenerative spine disease (DSD) is a prevalent condition that involves progressive structural deterioration of the spine, including intervertebral disc degeneration, spinal stenosis, and spondylosis [1]. It is a major cause of pain, functional limitations, and reduced quality of life globally, with increasing prevalence due to aging populations and lifestyle changes [2]. While genetic predisposition and aging are primary contributors, modifiable factors such as physical activity significantly influence the development and progression of DSD.

Physical activity has a complex role in spinal health. Moderate-intensity exercises, such as walking or swimming, are associated with reduced pain and enhanced function by improving spinal muscle support and promoting intervertebral disc hydration and nutrition. Meta-analyses have shown that walking, for instance, can effectively alleviate pain and improve function in individuals with chronic low back pain, a common symptom of DSD. However, repetitive or high-impact activities, such as heavy lifting or contact sports, may accelerate degenerative changes by imposing mechanical stress on spinal structures. This suggests a dose-dependent effect of physical activity on spine health, wherein excessive or improper activity can be detrimental [3].

In addition to direct mechanical effects, regular physical activity exerts systemic benefits, such as reducing inflammation and improving overall musculoskeletal resilience, which indirectly protect the spine. Emerging research also highlights how individual factors - such as age, pre-existing spine conditions, and occupation - modulate the impact of physical activity on DSD risk [4]. For example, younger adults exposed to repetitive occupational stress may face a higher risk of accelerated degeneration compared to older adults benefiting from controlled, low-impact exercise.

This review synthesizes current evidence on the role of physical activity in DSD, with a focus on identifying types and intensities of exercise that support spine health while mitigating risks. Insights from this analysis aim to inform targeted prevention and management strategies for those at risk of or living with DSD.

MATERIALS AND METHODS

A comprehensive literature review was conducted using PubMed and Google Scholar, focusing on studies published between 2000 and 2024. The search strategy aimed to gather an extensive range of research on the role of physical activity in the development and progression of degenerative spine disease. Key search terms included “physical activity, “degenerative spine disease,” “spinal degeneration,” “disc health” and “spinal health and exercise.” Inclusion criteria emphasized clinical trials, randomized controlled trials, cohort studies, systematic reviews, and meta-analyses examining how physical activity affects DSD onset, progression, or related outcomes, such as pain, mobility, or disc integrity. Studies were excluded if they focused solely on non-degenerative spine conditions or interventions unrelated to physical activity. Data were extracted systematically to categorize findings by exercise type (low-impact, high-impact, or occupational), intensity, and individual factors like age and pre-existing spine conditions. This method ensured the inclusion of high-quality, relevant research to provide a comprehensive understanding of the complex relationship between physical activity and DSD development.

RESULTS

The literature review included a variety of studies examining the impact of physical activity on degenerative spine disease (DSD), spanning multiple aspects of spinal health, such as disc degeneration, osteoarthritis of the facet joints, and spinal mobility. The studies ranged from observational analyses and clinical trials to systematic reviews and meta-analyses. The findings were categorized based on exercise type, intensity, duration, and individual factors such as age, existing spine conditions, and occupation.

Moderate Physical Activity:

Several studies suggest that moderate physical activity plays a protective role in the preservation of intervertebral discs and spinal structures. For example, a study by Vanti et al. showed that low-impact aerobic exercise, such as walking and swimming, can improve the hydration of intervertebral discs and reduce the rate of degeneration [5, 6]. The beneficial effects were attributed to improved blood flow and nutrient exchange, which help to maintain disc health . Regular exercise also appears to stimulate the production of key proteins

involved in disc repair, such as collagen and proteoglycans, which are crucial for disc function and resilience . In contrast, some studies indicated that excessive mechanical loading, such as high-impact or repetitive stress activities, may accelerate disc degeneration [7]. This phenomenon was particularly evident in individuals with pre-existing spinal pathology or those who performed these activities without adequate spinal support. The study emphasized the importance of understanding the type and intensity of physical activity to avoid exacerbating disc degeneration, especially in vulnerable populations.

Strengthening Exercises and Spinal Stability:

Strengthening exercises, particularly those focusing on core muscle groups, have been shown to improve spinal stability and function in individuals with degenerative spine conditions [8]. Kim et al. demonstrated that core stability exercises reduce pain and improve functional capacity in individuals with chronic low back pain due to degenerative changes in the spine. Strengthening exercises help support the spine by enhancing the endurance and strength of the paraspinal and abdominal muscles, which play a key role in maintaining spinal alignment and reducing mechanical stress on the intervertebral discs [9].

A randomized controlled trial revealed that a core strengthening program reduced pain and disability in patients with chronic low back pain caused by degenerative disc disease [10]. Furthermore, resistance training exercises that focus on the abdominal, back, and pelvic muscles have been shown to enhance spinal stability and decrease mechanical stress on degenerating discs. Strengthening exercises may also prevent future degeneration by maintaining proper spinal alignment and reducing the risk of disc herniation.

Flexibility Exercises:

Flexibility exercises are vital for maintaining range of motion in the spine and reducing stiffness in individuals with degenerative spine diseases. Research indicates that activities such as yoga and Pilates improve spinal flexibility and alleviate pain associated with degenerative conditions. A systematic review by Cramer et al. found that yoga, which combines stretching, strength, and mindfulness, significantly improved pain relief and spinal mobility in individuals with intervertebral disc degeneration [11]. Yoga was shown to enhance flexibility, reduce muscle tension, and improve spinal alignment, all of which contribute to reduced pain and better functional outcomes [12].

Similarly, Pilates exercises, which focus on strengthening core muscles while increasing spinal flexibility, were found to be beneficial for individuals with chronic low back pain and disc degeneration. Li et al. reviewed multiple studies and concluded that Pilates exercises improved spinal mobility, reduced pain, and enhanced functional capacity in patients with DSD [13]. Pilates also promotes better posture and body mechanics, which are essential for minimizing the effects of spinal degeneration.

Aerobic Exercise:

Aerobic exercise has systemic benefits that extend beyond spinal health, including the reduction of inflammation, which plays a significant role in the progression of degenerative spine diseases. Regular aerobic activity such as walking, swimming, and cycling has been shown to reduce systemic inflammation, which is commonly elevated in patients with degenerative conditions like intervertebral disc degeneration. A study demonstrated that moderate aerobic exercise significantly reduced levels of inflammatory markers, such as C-reactive protein (CRP) and interleukin-6 (IL-6), in patients with chronic low back pain. The reduction in inflammation can potentially slow the degenerative processes that affect the spine. [14]

Aerobic exercise is also crucial for weight management, which is another key factor in the prevention of degenerative spine diseases. By reducing excess body weight, which places additional mechanical stress on the spine, aerobic exercises can help mitigate the impact of spinal degeneration. Samartzis et al. observed that individuals who maintained a healthy weight through regular aerobic exercise had a lower incidence of disc degeneration and related pain, compared to those who were overweight or sedentary [15].

Age and Gender:

Age and gender are important considerations when prescribing exercise interventions for individuals with degenerative spine diseases. Older adults, in particular, benefit from low-impact aerobics activities and strengthening exercises, which help combat age-related declines in spinal health. Rice et al. found that older adults who participated in regular physical activity experienced improved spinal mobility, reduced pain, and better overall function [16]. Exercise also helps counteract the natural loss of bone density and muscle mass that occurs with aging, both of which contribute to the development and progression of DSD.

Gender differences in exercise outcomes have also been observed. Postmenopausal women are at higher risk for developing osteoporotic changes in the spine, which can exacerbate degenerative disc disease. Some studies found that weight-bearing exercises, such as resistance training, significantly improved bone density and spinal stability in postmenopausal women, potentially reducing the severity of degenerative changes [17, 18]. For both men and women, personalized exercise regimens based on individual health status, gender, and age-related risks are essential for optimizing outcomes in managing degenerative spine conditions.

Exercise Prescription:

While physical activity offers significant benefits for individuals with degenerative spine diseases, certain challenges exist in determining the appropriate exercise regimen. High-impact exercises or intensive activities may exacerbate symptoms in patients with advanced degenerative changes or those with significant pain. A study highlighted that high-intensity exercises could worsen pain in patients with severe degenerative changes [19]. As such, a gradual and individualized approach is necessary, beginning with low-impact exercises and progressing to more intensive activities as tolerated.

It is also important to incorporate multidisciplinary interventions, such as physical therapy and cognitive-behavioral strategies, to enhance the effectiveness of exercise and improve adherence [20]. Combining exercise with manual therapy, posture education, and patient engagement in self-management techniques has been shown to improve outcomes for individuals with degenerative spine diseases [21].

DISCUSSION

The relationship between physical activity and degenerative spine disease is complex, with evidence supporting both the beneficial and potentially harmful effects of exercise, depending on the type, intensity, and duration of the activity. This review highlights key findings regarding the impact of physical activity on the prevention, progression, and management of degenerative spine conditions, such as intervertebral disc degeneration, spinal osteoarthritis, and chronic low back pain.

Moderate Physical Activity:

The evidence suggests that moderate physical activity, especially low-impact exercises like walking, running swimming, and cycling, can have a protective effect on spinal health by improving the hydration and metabolism of intervertebral discs [6]. The intervertebral discs rely on intermittent loading to maintain nutrient exchange and prevent degeneration, as the disc's avascular nature limits direct blood supply. Research indicates that regular physical activity promotes disc hydration and metabolism, which in turn may delay or prevent the progression of disc degeneration. Specifically, mechanical loading from moderate-intensity exercise increases the flow of nutrients into the discs, which helps maintain their structure and function [7]. However, it is essential to note that while moderate exercise has positive effects, high-impact activities or excessive repetitive loading can contribute to disc wear and tear. A study found that high-intensity physical activity without adequate recovery may accelerate the degenerative process, particularly in individuals with pre-existing spinal conditions [19]. This highlights the need for individualized exercise prescriptions that balance physical activity with adequate rest.

Strengthening Exercises and Spinal Stability:

Strengthening exercises, particularly those targeting core and paraspinal muscles, have been shown to improve spinal stability and reduce the risk of exacerbating degenerative changes [9]. Strengthening exercises can alleviate mechanical stress on the intervertebral discs by promoting optimal spinal alignment and improving the function of the muscles that support the spine. A significant body of evidence suggests that strengthening exercises, such as those aimed at improving the core muscles, can help manage chronic low back pain and reduce disability caused by degenerative spine conditions [10].

Flexibility Exercises:

Flexibility exercises have demonstrated efficacy in improving spinal mobility and relieving symptoms of spinal degeneration. Studies have shown that activities like yoga and Pilates significantly enhance spinal flexibility, reduce muscle tension, and improve posture [11, 12]. These exercises focus on dynamic movements that increase range of motion and spinal alignment, which can help alleviate pain and stiffness associated with degenerative changes. Yoga and Pilates promote relaxation and mindfulness, which can further contribute to pain reduction through mechanisms such as decreasing muscle tension and improving mental well-

being. Moreover, these exercise forms are beneficial for older adults, helping to counteract age-related declines in spinal flexibility and mobility [13].

Aerobic Exercise:

Aerobic exercise plays a crucial role in reducing systemic inflammation, a key factor in the pathogenesis of degenerative spine diseases. Chronic low back pain and disc degeneration are often associated with elevated levels of pro-inflammatory cytokines, such as interleukin-6 and C-reactive protein [14]. Regular aerobic exercise has been shown to lower these inflammatory markers, which may contribute to pain reduction and the slowing of degenerative processes in the spine. Additionally, aerobic exercises such as walking, cycling, and swimming help manage body weight, which in turn reduces mechanical load on the spine. By reducing excess body weight, these exercises decrease the strain on intervertebral discs and surrounding structures, which is particularly important in individuals with obesity or overweight, both of which are risk factors for the development and progression of DSD [15]. Aerobic exercise also improves cardiovascular health, which further supports the circulation of nutrients to the spine.

Age and Gender:

The response to physical activity may vary based on age and gender, with specific considerations needed for different populations. Older adults may experience greater benefits from exercise in terms of preserving spinal mobility and reducing pain associated with degenerative spine diseases [16]. As age progresses, individuals are more likely to experience a decrease in bone mineral density and muscle mass, both of which contribute to the worsening of spine health. Regular exercise can help mitigate these declines, especially through weight-bearing activities like resistance training, which has been shown to increase bone density and prevent further degeneration of spinal structures [17].

Gender differences also influence the outcomes of exercise interventions. For instance, postmenopausal women, who are more likely to develop osteoporosis and experience increased spinal fragility, may particularly benefit from strength training and resistance exercises to improve bone density and spinal stability [18]. Gender-specific exercise programs that combine aerobic, resistance, and flexibility training could be more effective in addressing the unique risks faced by men and women with degenerative spine diseases.

Exercise Prescription:

Despite the proven benefits of physical activity, exercise prescription for patients with degenerative spine diseases remains a challenging aspect of treatment. The intensity and type of exercise must be carefully considered to avoid exacerbating symptoms or causing further injury [19]. High-impact or high-intensity activities can worsen symptoms in individuals with advanced degeneration, particularly those with disc herniations or spinal stenosis. Moreover, the implementation of exercise programs requires patient education and adherence. Many individuals with degenerative spine diseases experience fear-avoidance behaviors, which may limit their participation in physical activities [20]. Cognitive-behavioral strategies, alongside physical rehabilitation, are essential in overcoming these barriers to exercise. Additionally, a multidisciplinary approach, including manual therapy and educational interventions on body mechanics, can enhance the effectiveness of exercise-based rehabilitation programs for patients with degenerative spine diseases [21].

CONCLUSIONS

The review of current literature demonstrates that physical activity plays a crucial role in the development, prevention, and management of degenerative spine diseases (DSD), including intervertebral disc degeneration, spinal osteoarthritis, and chronic low back pain. Evidence consistently highlights that appropriate exercise types, such as aerobic, strength, and flexibility training, contribute to maintaining spinal health, reducing pain, and slowing disease progression.

Moderate-intensity exercises, particularly low-impact aerobics activities like walking, swimming, and cycling, enhance intervertebral disc hydration and improve metabolic exchange within the discs, delaying degenerative processes. Core-strengthening and resistance training effectively reduce mechanical stress on the spine and improve spinal stability, leading to decreased pain and improved functional outcomes. Flexibility-focused exercises like yoga and Pilates promote spinal mobility, alleviate muscle tension, and improve posture, providing essential therapeutic benefits. Aerobic exercise has also been shown to reduce systemic inflammation, a key driver of degenerative processes in spinal tissues. Regular physical activity lowers inflammatory markers like C-reactive protein and interleukin-6, contributing to symptom relief in chronic LBP and IDD. Additionally, weight management through

exercise reduces mechanical stress on the spine, further mitigating degenerative changes. While the benefits of physical activity are evident, exercise regimens must be carefully prescribed based on individual patient characteristics such as age, gender, disease stage, and functional capacity. For older adults, resistance and flexibility training can preserve bone density and spinal mobility, reducing the severity of degenerative changes. However, high-intensity or improper exercise may exacerbate symptoms in individuals with advanced degeneration. A personalized approach that considers patient-specific risk factors is essential to optimize therapeutic outcomes. To maximize benefits, exercise should be integrated into a broader rehabilitation strategy involving physical therapy, patient education, and cognitive-behavioral interventions. Addressing psychological barriers such as fear-avoidance behaviors can enhance treatment adherence and long-term success.

Given the substantial evidence, promoting regular, well-structured physical activity should be a central component of preventive and therapeutic strategies for managing degenerative spine diseases. Tailored exercise programs, guided by clinical expertise, can significantly enhance spinal health, reduce disability, and improve the overall quality of life for affected individuals. Future research should explore more precise exercise protocols and their long-term outcomes in diverse patient populations.

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