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The Role of Physical Activity in the Prevention and Management of Chronic Low Back Pain: A Health Education and Sport Science Perspective

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Abstract

Introduction: Chronic low back pain (CLBP) remains a critical challenge for public health and physical culture, significantly impacting quality of life and generating substantial healthcare costs. In the context of health education, a sedentary lifestyle is identified as a primary modifiable risk factor that requires targeted movement-based interventions.

Objective: This review aims to synthesize current evidence on the role of physical activity in both the prevention and management of CLBP. Particular emphasis is placed on the physiological mechanisms of exercise and the pedagogical effectiveness of various sports-related interventions.

Methods and Materials: A narrative review was conducted based on literature published between 2006 and 2026. The analysis included cohort studies, randomized controlled trials (RCTs), and meta-analyses focusing on diverse modalities, including core stabilization, aerobic training, Pilates, yoga, and aquatic exercises.

Results: Regular engagement in physical activity effectively reduces the risk of CLBP occurrence and recurrence by enhancing muscular endurance, spinal stability, and neurobiological pain modulation. Notably, the review finds that interventions integrating physical exercise with health education (e.g., postural awareness and movement ergonomics) yield superior outcomes in reducing kinesiophobia (fear of movement) and functional disability compared to exercise alone.

Conclusions: Physical activity should be promoted as a primary health-seeking behavior in CLBP care. To optimize public health outcomes, individually tailored exercise programs should be integrated with educational strategies, positioning sport and physical culture as essential components of modern spinal health management.

Keywords: chronic low back pain, physical activity, health education, sports science, core stabilization, kinesiophobia, health promotion.

Introduction

1. Definition and Clinical Classification of Low Back Pain

Low back pain (LBP) is defined as a condition, located in the posterior part of the trunk, anatomically bounded proximally by the lower edge of the twelfth rib and distally by the inferior gluteal folds, and which may radiate to one or both lower limbs [1].

The basic temporal classification differentiates pain into acute (lasting less than 6 weeks), subacute (lasting 6 to 12 weeks), and chronic (Chronic Low Back Pain – CLBP, defined as symptoms persisting for more than 12 weeks). Chronic LBP is often associated with the persistence of dysfunctional movement patterns [2]. Diagnostic classification categorizes patients into three main groups, the largest of which, accounting for approximately 90% of cases, is nonspecific back pain. In this clinical presentation, it is impossible to clearly link symptoms to a specific anatomical structure or systemic pathology, making physical activity the gold standard of therapeutic management. Other groups include specific pain resulting from distinct structural changes, such as radiculopathy or spinal stenosis, and rare but clinically significant cases associated with serious systemic pathology, referred to as „red flags"[3]. From the perspective of kinesiotherapy programming, classification based on dominant neurophysiological mechanisms is also crucial. A distinction is made between nociceptive pain, generated by irritation of peripheral tissues, neuropathic pain associated with damage to neural structures, and nociplastic pain, resulting from impaired modulation of signals in the central nervous system, known as central sensitization [4]. Precise identification of these components allows for the use of targeted exercise therapy, which in patients with nociplastic pain should place greater emphasis on education and gradual exposure to loading, and in patients with nociceptive pain – on the optimization of biomechanics and motor control [2].

2. Global Epidemiology and Prevalence Rates

LBP remains one of the leading causes of years lost to disability (YLD) worldwide. In 2025, the number of people affected by this condition in the working-age population was estimated to be approximately **452,8 million**, representing a **52,66% increase compared to 1990**, and the global number of cases in the general population continues to rise, making LBP a growing public health problem [1]. It is estimated that up to 80% of the population will experience at least one episode of LBP during their lifetime. Although acute LBP often resolves spontaneously within a few weeks, a considerable proportion of patients report recurrence within one year, and approximately 15% progress to chronic low back pain [5]. Low back pain can affect all age groups, including children, adolescents, and adults. It is estimated that the vast majority of the population will experience at least one episode of low back pain during their lifetime, underscoring its widespread nature. The highest incidence is observed in people aged around 50–55, with women being more susceptible to this condition than men. Furthermore, the frequency of recurrences of low back pain increases with age, suggesting its tendency to be chronic and recurrent [6]. The above data indicate that low back pain is common and affects a wide range of populations, with particular severity among working-age individuals. This highlights the importance of early preventive measures and promoting physical activity as a key element in reducing the risk of occurrence and recurrence of the condition.

3. **Socioeconomic Burden and Public Health Impact**

The decade 2020–2030 designated by the United Nations as the „Decade of Healthy Aging", provides a platform for to strengthening national and global efforts to reduce the burden of LBP through education and promotion of physical activity. Furthermore, LBP generates significant **health and economic costs**, including medical and rehabilitation expenses, as well as losses related to absenteeism and reduced productivity, further underscoring its importance for public health policy [7]. Recurrent low back pain is a key determinant of the direct financial costs incurred as part of the therapeutic process. Individual medical procedures are significantly more expensive than incidental cases, a trend that does not extend to the physiotherapy sector. Analysis of healthcare utilization revealed a clear sexual dimorphism: the male population is characterized by a higher frequency of hospitalizations, while the female population prefers outpatient physiotherapy interventions. The relative stability of physiotherapy costs in the course of recurrent LBP and its high prevalence among women suggest that non-pharmacological therapeutic strategies are a fundamental component of the clinical management of this condition. Low back pain is also a common cause of hospitalization, significantly impacting patient length of stay. Given the significant economic burden generated by patients with recurrent symptoms, the implementation of systemic secondary prevention strategies is becoming a priority. Promoting regular physical activity appears to be an effective method for reducing the frequency of relapses, which, from a macroeconomic perspective, can lead to significant optimization of public spending in the healthcare sector [8,9].

Etiology and Risk Factors

Nowadays, chronic low back pain is perceived as a multifactorial and multidimensional condition. The nature of the disease results from a dynamic synergy between biomechanical, psychosomatic (including the affective and cognitive sphere), behavioral and socioeconomic lifestyle determinants [5]. It is estimated that nearly 40% of the disease burden resulting from low back pain is determined by modifiable risk factors, particularly hypokinesia, dysfunctional postural patterns, and unergonomic work conditions [8]. Precise stratification and evaluation of the hierarchy of influence of individual components in a given patient are mandatory elements of an advanced diagnostic protocol. Such an approach is a prerequisite for individualized, multimodal clinical management, focused on the individual's specific phenotypic profile.

1. Physical Inactivity and Sedentary Lifestyle

The results of long-term cohort studies clearly indicate that sitting time is a significant risk factor for developing chronic low back pain. During the nearly 8-year follow-up period, chronic back pain occurred in 3,006 participants, representing 9% of the study population. More than half of these individuals reported pain when sitting for more than 4 hours per day. After adjusting for confounding variables, the risk of developing chronic back pain was 16% higher in individuals sitting for 4 to 6 hours per day, while those sitting for more than 6 hours per day had a 33% higher risk compared to those sitting for no more than 2 hours daily. Importantly, no significant increase in risk was observed among those sitting for 2–4 hours per day. It was observed that low levels of physical activity exacerbated the negative impact of prolonged sitting, while engaging in moderate physical activity with shorter sitting time significantly reduced the risk of developing chronic LBP. Moreover, even partial replacement of sedentary time with physical activity was associated with a significant reduction in the risk of pain. A chronic sedentary lifestyle, beyond its direct impact on the musculoskeletal system, may promote neurobiological changes, including increased neuroinflammatory processes, reduced levels of neurotrophic factors, and decreased volume in specific brain structures, which may predispose individuals to the development of chronic pain. In the context of the observed decline in daily physical activity and increasing time spent sedentary in modern populations, these factors become particularly important as modifiable determinants of LBP [10].

2. Structural Degeneration and Functional Insufficiency of Postural Musculature

Research on chronic low back pain highlights the complex relationship between degeneration of the lumbar paraspinal muscles and the persistence of pain symptoms. Increased fat infiltration within the paraspinal muscles has been shown to correlate positively with pain duration, whereas structural parameters reflecting better muscle condition—such as greater cross-sectional area (CSA) and functional cross-sectional area (FCSA) of the multifidus (MF)—are associated with improved quality of life in individuals with cLBP. These findings suggest that weakening of postural muscles, particularly those responsible for segmental spinal stabilization, may contribute to impaired stability and increased susceptibility to static overload [11]. The erector spinae muscle contributes more substantially to lumbar extension torque than the multifidus, whose contribution is estimated at approximately 20% of the total extensor moment in the lumbar spine. Therefore, deterioration in the structural quality of the erector spinae due to fat infiltration may impair lumbar biomechanics, reduce active spinal stabilization capacity, and ultimately facilitate the development of pain symptoms. Although the multifidus is frequently implicated in the etiology of LBP, the synergistic function of the entire paraspinal muscle complex should be considered in the pathogenesis of this condition [5,12]. Multisegmental assessment of the paraspinal muscles provides deeper insight into how muscle degeneration and reduced functional capacity may play a role in the development and maintenance of non-specific low back pain.

3. Lifestyle Determinants

Lifestyle and work-related factors play a significant role in the etiology and progression of low back pain. Excess body weight and obesity have consistently been identified as independent risk factors for pain and related disability, which may be related to both increased mechanical stress on the spine and inflammation of adipose tissue. Furthermore, smoking is associated with a higher incidence and recurrence of LBP, regardless of age, education, or physical activity level, suggesting a multifactorial behavioral influence on spine health. Interactions between environmental factors and occupational activities also contribute to the risk of LBP. Exposure to non-ergonomic loads, such as whole-body vibration, repetitive lifting of heavy loads, poor posture, and monotonous, mostly sedentary work activities, are associated with an increased risk of low back pain and radiculopathy [13]. Occupational factors, smoking, and high body mass index are estimated to account for approximately 38.8%

(confidence interval 28.7–47.0%) of the years lived with disability (YLD) associated with low back pain [9].
This suggests that preventive interventions aimed at reducing these factors—including improved ergonomics, weight management, and smoking—can have a significant impact on reducing the clinical and socioeconomic burden associated with chronic low back pain. This also highlights the potential of behavioral and educational interventions to reduce the frequency and severity of symptoms.

Comparative Analysis of Selected Exercise Modalities

The therapeutic effectiveness of physical activity in chronic low back pain is closely correlated with the precise identification of the dominant pathophysiological mechanisms. In cases with a predominant nociceptive component, where symptoms are strongly dependent on movement patterns and body posture, optimizing active stabilization and the structural and functional properties of the paraspinal muscles becomes a key element of intervention. Available data indicate that progressive training protocols—combining early neuromuscular reeducation with targeted resistance training—promote normalization of motor unit activation patterns and induce beneficial morphological adaptations of the spinal erectors. The contemporary kinesiotherapy paradigm assumes that improving the efficiency of the biomechanical system requires gradual exposure to stimuli of increasing intensity, going beyond traditional protective strategies. An integral part of this process is the integration of strength training with sensorimotor control components, tailored to the patient's individual deficits, such as segmental stabilization disorders or multifidus insufficiency [5]. The following analysis compares selected movement methods, assessing their unique impact on pain reduction and functional recovery in the CLBP population.

1. Core stability training

Analysis of data from five published studies of high methodological quality (PEDro score: 5–8) confirms that core stability exercises (CSE) are an effective adjunct in the treatment of nonspecific lower back pain (NSBP). The analyzed data were statistically analyzed using a security reader and functionally assessed using standardized tools, including the Oswestry Certification of Qualification (MODQ) [14]. Core Stability Exercise (CSE) interventions impact not only the manifestation of clinical symptoms but, above all, fundamental neuromuscular mechanisms. Implementation of structured therapeutic programs induces measurable morphological and functional changes, manifested by increased cross-sectional area (CSA) and improved recruitment patterns of the transversus abdominis (m. transversus abdominis) and multifidus muscles. Research indicates that the effectiveness of core stabilization strategies remains independent of the duration of pain symptoms. Analysis of patients with CLBP showed that, both in the group with a shorter history of symptoms (3–12 months) and in those with persistent pain (over 1 year), this training leads to clinically significant reductions in pain and disability, while simultaneously activating the strength of the transversus abdominis and gluteus maximus muscles [15].

Improvements in proprioception and postural control noted in the literature indicate a stimulating effect of training on the sensorimotor system and segmental stabilization of the spine. Focusing the rehabilitation process on selective activation of deep muscles and synergistic strengthening of the posterior band, while simultaneously improving strength and endurance parameters, promotes the restoration of physiological active stiffness of the lumbopelvic complex during daily activities. Early implementation of motor control exercises is therefore a key component of a therapeutic strategy aimed at reducing functional deficits and minimizing the risk of further chronicity of pain symptoms, regardless of the clinical stage of the condition.

2. Aerobic exercises

Aerobic training is an integral component of multimodal therapy for low back pain (LBP), inducing adaptations in both the peripheral and central pain modulation structures. Systematic moderate-intensity activity (e.g., walking, cycle ergometer), performed 3–5 times per week for a minimum of 6–12 weeks, achieves clinically significant pain reduction—estimated at an average of 1.5–2 points on the VAS scale—and measurable improvements in functional capacity, as assessed by the Oswestry Disability Index (ODI). From a biomechanical perspective, cyclic aerobic loading optimizes the strength of local and global spinal stabilizers, promoting the effective distribution of compressive forces within the lumbar segments. A key neurophysiological mechanism is the phenomenon of exercise-induced hypoalgesia (EIH). Short-term exposure to exercise (20–30 minutes at an intensity of 60–75% HRmax) stimulates endogenous opioid and cannabinoid systems, leading to a transient increase in pain threshold. In the long term, aerobic training promotes the suppression of low-grade systemic inflammation and strengthens descending pain inhibitory pathways. Furthermore, regular aerobic activity demonstrates strong potential for modifying psychosocial factors – through anxiety desensitization, it reduces kinesiophobia and curbs avoidance behavior, which is crucial in disrupting the chronicity of LBP. Due to their high availability, favorable safety profile, and low implementation cost, aerobic protocols (with particular emphasis on walking) are the recommended standard for the primary and secondary prevention of spinal dysfunction [16].

3. Pilates

The Pilates method is a specific form of neuromuscular training based on six paradigms: centering (activation of core structures), concentration, control, precision, respiratory coordination, and fluidity of movement. Therapeutically, this method focuses on the selective recruitment of deep core stabilizers, which promotes the restoration of segmental spine stabilization and optimizes postural control. Systematic implementation of this protocol leads to increased strength and endurance of local muscles, improved synergy between muscle groups, and a reduction in pathological compressive loads within the spinal motor segments. By correcting pelvic positioning and promoting a neutral spine position, Pilates limits the overstimulation of nociceptive receptors, which directly translates into desensitization of lumbar structures and pain reduction.

Recent clinical reports indicate that Pilates is highly effective in improving function and reducing symptoms in patients with chronic, nonspecific low back pain, and the therapeutic effects achieved tend to persist during the follow-up period after the exercise program is completed. By integrating local stabilization with global movement patterns, this method enhances sensorimotor control and kinesthetic precision, enabling ongoing self-correction of postural abnormalities [17].

However, despite the documented impact on physical parameters, meta-analyses do not unequivocally confirm a significant effect of Pilates on improving overall quality of life (QoL) in this population, suggesting that the mechanisms of functional improvement do not always directly correlate with the patient's subjective psychosocial well-being. Current literature also highlights significant research gaps, including the lack of clear data regarding the safety profile of this form of therapy and the unclear optimal training dose (frequency and intensity of intervention). Therefore, it is necessary to standardize future research protocols and incorporate objective measurement tools, such as electromyography (EMG) or magnetic resonance imaging (MRI), to precisely assess morphological and neurophysiological changes. This approach will allow for a more comprehensive explanation of the mechanisms of action of the Pilates method and strengthen the scientific evidence base (EBM) regarding its role in the long-term rehabilitation process of CLBP [18].

4. Yoga

In recent years, the medical community has seen growing interest in yoga as a complementary, non-pharmacological treatment for chronic low back pain (CLBP). Meta-analyses based on randomized controlled trials (RCTs) indicate that systematic yoga practice induces significant reductions in pain symptoms and functional limitations, with the therapeutic effect immediately following the intervention being assessed as moderate to large. Although the dynamics of these changes diminished somewhat during the follow-up period, the benefits remain statistically significant, suggesting the relative durability of adaptations induced by the exercise program [19]. Accumulating evidence suggests that various yoga modalities—including Hatha, Iyengar, and Viniyoga—produce comparable clinical outcomes. This indicates a universal mechanism of action, based on the synergy of strengthening muscle strength, improving soft tissue flexibility, and precise breath control and concentration. Yoga optimizes spinal function by selectively activating deep trunk stabilizers, improving segmental stabilization, and reintegrating neuromuscular control. Its impact on neuropsychology is equally significant: by alleviating pain hypervigilance and reducing movement anxiety, yoga effectively counteracts the mechanisms of kinesiophobia, which directly translates into improved mental well-being in patients [19, 20]. One of the key advantages of yoga in the clinical context is its high safety profile and excellent patient adherence to recommendations, demonstrated by low dropout rates. The broad demographic profile of individuals using this form of activity suggests its universal application, regardless of age or gender [20]. However, the interpretation of study results faces certain methodological limitations, such as significant protocol heterogeneity and the presence of nonspecific treatment effects in control groups. This indicates an urgent need for further RCTs comparing yoga with other active interventions (e.g., Pilates or cognitive-behavioral therapy) to precisely determine the optimal training dose and the mechanisms mediating analgesia [19].

5. Aquatic exercises

Aquatic interventions are a recognized standard in the rehabilitation of patients with musculoskeletal dysfunctions, utilizing the unique physical properties of water for therapeutic purposes. The effects of hydrostatic pressure and buoyancy promote the reduction of peripheral edema, modulation of sympathetic nervous system activity, and structural relief of lumbar segments. Meta-analyses demonstrate that active forms of aquatic therapy demonstrate a high safety profile and effectiveness in reducing pain intensity (measured by the VAS scale) and improving functional capacity in individuals with chronic low back pain. Although the heterogeneity of available studies—resulting from differences in session frequency and symptom duration—makes it difficult to precisely formulate uniform guidelines, aquatic exercise is recommended as an essential component of comprehensive rehabilitation programs, correlating with improved physical quality of life [21]. Modern research approaches extend the analysis of aquatic therapy to assess the impact of specific swimming styles on acute pain responses. Recent reports indicate subtle differences in subjective discomfort depending on swimming technique: the lowest pain values were reported during backstroke, while the highest were reported during breaststroke. However, it should be noted that these differences have limited clinical significance and often do not reach therapeutic thresholds. Importantly, patients' choice of a specific swimming style is determined not only by their level of physical comfort but also by subjective factors such as a sense of safety and technical ease of execution [22].

In conclusion, general aquatic activity and regular swimming demonstrate greater clinical significance for reducing disability and improving functioning than the choice of swimming technique alone. Given the methodological limitations of previous studies, such as small sample sizes and varying quality of reports, continued work on standardizing aquatic protocols is necessary to fully verify their long-term effectiveness in the LBP population [21,22].

Primary and Secondary Prevention: Neurobiological and Structural Protective Mechanisms of Systematic Physical Activity

The identification of a sedentary lifestyle and hypokinesia as key, modifiable risk factors for chronic low back pain (CLBP) prioritizes preventive measures.

Current reports, including multicenter cohort studies, indicate that regular physical activity plays a protective role not only structurally but also neuroanatomically. Exercise promotes the maintenance of normal brain volume and reduces systemic inflammatory processes, which underlie chronic pain. Consequently, regular physical activity becomes a preventative measure with a dual vector of action: it

optimizes the biomechanics of the musculoskeletal system by improving active stabilization and endurance, while simultaneously modulating the neurophysiological mechanisms of pain perception in the central nervous system [10]. The effectiveness of preventive strategies is closely dependent on their comprehensiveness. Meta-analyses demonstrate that programs integrating targeted physical exercise with health education are more effective in preventing nonspecific episodes of LBP than single-component interventions. This integrated approach not only reduces pain episodes but, above all, effectively reduces functional disability and kinesiophobia. Patient education, supported by systematic movement, breaks the "vicious cycle" of pain, reducing fear of activity and catastrophizing, which is crucial in high-risk populations such as sedentary workers, students, and professional drivers [23]. In the context of training parameters, the literature indicates the need for appropriate consistency – programs performed at least three times a week for 6–12 weeks generate the most measurable clinical benefits [15]. Aquatic exercise can play a special role in secondary prevention. Thanks to buoyancy, it reduces axial load on the spinal structures, enabling safe progression of exercise intensity. RCTs confirm that therapeutic aquatic exercise leads to lasting improvements in function, and its effectiveness is independent of demographic factors such as age or body mass index (BMI) [24].
A holistic approach, combining various forms of exercise (stabilization, aerobic training, mobilization) with an individually tailored training regimen, is currently the most effective model for reducing the long-term health and socioeconomic consequences associated with LBP.

Limitations

Despite strong evidence supporting the effectiveness of physical activity in the treatment of chronic low back pain, this review faces significant limitations stemming from the nature of the available literature. The significant heterogeneity of the analyzed interventions remains a fundamental methodological challenge. Significant differences in training protocols—including exercise types, frequency, intensity, and total program duration—make it difficult to precisely formulate unified treatment guidelines and directly compare results between individual modalities. Another significant limiting factor is the methodological quality of some of the included studies. Limited sample sizes in some analyses reduce statistical power, making it difficult to detect subtle differences between study groups. There is also a lack of widespread use of objective assessment methods, such as electromyography or magnetic resonance imaging, which would allow for a reliable analysis of changes in neuromuscular control and anatomical structures. It should also be emphasized that the available data do not always allow for a clear assessment of the long-term safety profile and the impact of exercise on patients' overall quality of life. Although improvements in physical parameters are observed, they do not always correlate directly with subjective psychosocial well-being. Furthermore, in many cases, a tendency for the dynamics of therapeutic effects to weaken during the follow-up period after the completion of supervised exercise programs is noted, indicating difficulties in maintaining long-term patient adherence to independent activity. All these factors point to an urgent need for standardized future research designs to strengthen the scientific evidence regarding the effectiveness of exercise in CLBP treatment.

Summary and Conclusions

The contemporary paradigm of evidence-based medicine (EBM) positions physical activity as the first-line intervention in the prevention and treatment of chronic low back pain. Implementing individually tailored, multi-component exercise programs optimizes clinical outcomes, manifesting as significant pain reduction and measurable improvements in functional performance. The therapeutic mechanism of exercise is multidimensional: from a biomechanical perspective, regular training improves lumbar stabilization and optimizes structural load distribution, while from a neurophysiological perspective, it stimulates endogenous pain inhibition systems, reduces systemic inflammation, and supports the maintenance of normal volume within the central nervous system.

A review of current research confirms the particular effectiveness of methods focused on motor control and trunk stabilization, such as core stabilization training (CSE), Pilates, and yoga. By increasing postural awareness and correcting abnormal movement patterns, these forms effectively reduce the overstimulation of nociceptive receptors. At the same time, aquatic exercise plays a significant role. Its hydrostatic properties enable safe progression of exercise with minimal axial load on the spine, which translates into high patient adherence and a lasting improvement in their quality of life.

A key conclusion from the literature review is the advantage of systematically undertaken activity over its occasional intensity. Regular repetition of movement stimuli (ideally three times per week for a minimum of 6–12 weeks) induces lasting adaptations within the neuromuscular system, which forms the foundation of secondary prevention and prevents recurrence of pain episodes. Integrated programs combining movement with health education demonstrate the highest preventive effectiveness. By reducing kinesiophobia and pain catastrophization, they effectively counteract the processes of pain chronification. Despite the existing heterogeneity of training protocols, the accumulated scientific evidence clearly indicates that widespread implementation of physical activity-based strategies is crucial for reducing the socioeconomic consequences of low back pain and improving population health.

Authors' contributions:

Conceptualization IS; Methodology KW; Software KW; Check JS, KW; Formal analysis JS; Investigation IS; Resources KW; Data curation IS; Writing-rough preparation JS; Writing review and editing KW, IS; Visualization JS; Supervision IS; Project administration JS;

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