

Clinical Outcome of Multimodal Therapy in Low Back Pain

Clinical study on 210 patients



Marko Kosić, PhD

Ph.D. Marko Kosić

***CLINICAL OUTCOME OF MULTIMODAL
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CLINICAL STUDY ON 210 PATIENTS***

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About the Author

Marko Kosić, PhD, was born in Zagreb, Croatia. He is a healthcare professional, scientist, and academic practitioner whose work integrates clinical expertise, scientific research, and healthcare system leadership. He holds a doctoral degree in Biomedicine and Health Sciences, obtained through the doctoral program at the Faculty of Medicine, University of Rijeka, where his scholarly training focused on advanced clinical research methodologies, evidence-based practice, and the application of biomedical science to rehabilitation and physical medicine.

Dr. Kosić's academic background is characterized by a strong interdisciplinary orientation and an exceptional breadth of formal education. He has completed three university-level degrees in the field of health sciences, encompassing undergraduate, graduate, and postgraduate studies. In addition to his doctoral education, he earned both a bachelor's and a master's degree from accredited health science faculties, achieving the professional titles of Master of Physiotherapy and Specialist in Orthopedic Musculoskeletal Physiotherapy. His postgraduate specialization provided advanced competencies in the assessment, diagnosis, and management of complex musculoskeletal and orthopedic conditions, with a particular emphasis on clinical reasoning, functional restoration, and long-term patient outcomes.

He is the founder, owner, and director of the Kosić Healthcare Institution for Nursing and Rehabilitation, a specialized healthcare facility dedicated to comprehensive rehabilitation, long-term care, and interdisciplinary treatment approaches. Furthermore, Dr. Kosić is the founder, owner, and Chief Executive Officer of KOSIĆ Marko Ltd., a healthcare-oriented company focused on professional services, clinical development, and organizational management within the rehabilitation sector. Through these roles, he actively contributes to the design, implementation, and evaluation of patient-centered care models, while also overseeing institutional governance, quality assurance, and strategic development.

Since 2014, Dr. Kosić has served as an external associate at Poliklinika Drinković, within the Department of Physical Medicine and Rehabilitation, where he collaborates with physicians and multidisciplinary healthcare teams in the management of patients with

musculoskeletal, orthopedic, neurological, and post-traumatic conditions. His clinical practice is grounded in evidence-based rehabilitation, combining contemporary scientific knowledge with individualized therapeutic strategies tailored to functional goals and patient-specific needs.

Over the course of his career, Dr. Kosić has gained extensive professional experience in several of Croatia's most prominent healthcare institutions. His previous appointments include clinical and professional roles at Sveti Ivan Psychiatric Hospital, Clinical Hospital Centre "Sestre milosrdnice", Vrapče Psychiatric Hospital, and the Clinic for Traumatology. These positions provided him with broad exposure to acute, chronic, and complex clinical populations, strengthening his expertise in interdisciplinary collaboration and comprehensive rehabilitation planning across psychiatric, orthopedic, and trauma-related settings.

*In parallel with his clinical and managerial activities, Dr. Kosić maintains a strong and continuous engagement in scientific research and academic dissemination. He actively participates in national and international scientific conferences, where he contributes as an author, co-author, and presenter of professional and scientific work in the fields of physiotherapy, rehabilitation medicine, and healthcare organization. He is the author and co-author of numerous professional and peer-reviewed scientific publications. As the first author, he published a scientific article in the internationally indexed journal *Medical Science Monitor*, addressing clinically relevant topics within biomedical and rehabilitation research.*

*In addition to his publication record, Dr. Kosić serves as a peer reviewer for two internationally recognized, U.S.-based scientific journals: *Medical Science Monitor* and the *American Journal of Case Reports*. Through this role, he contributes to the critical appraisal of scientific manuscripts, supporting methodological rigor, ethical standards, and the advancement of evidence-based knowledge in clinical medicine and allied health sciences.*

Dr. Kosić is widely recognized for his advanced communication, leadership, and organizational skills, as well as for his ability to bridge scientific theory with clinical practice and healthcare management. His professional and academic interests include

orthopedic and musculoskeletal rehabilitation, clinical decision-making processes, rehabilitation outcomes research, healthcare system organization, and the implementation of scientific evidence into everyday clinical and institutional practice. He is particularly committed to the continuous development of professional standards in physiotherapy and to fostering high-quality, sustainable healthcare systems.

He is married and the father of three children. Alongside his professional and academic commitments, he considers family life an essential source of personal stability and long-term motivation. His work reflects a sustained dedication to scientific excellence, clinical integrity, and the improvement of patient care through interdisciplinary collaboration, research-driven practice, and responsible healthcare leadership.

Preface

From the earliest records of human disease to contemporary medical documentation, spinal pain has consistently appeared as one of the most common and most prominent pathological conditions. Even in the time of Galileo, during an era of profound technological, scientific, and social transformation, people—despite relatively high levels of physical activity and the absence of today’s sedentary lifestyle—suffered from various spinal deformities and painful syndromes. Historical medical records, illustrations, and descriptions of manual interventions testify that the lumbar region has always represented a kind of “weak point” of the human body—a region where biomechanical loading, occupational strain, aging, and disease converge.

With the development of industrialization, increased life expectancy, and changes in lifestyle, low back pain syndrome (LBPS) has evolved from an individual clinical problem into one of the major public health challenges of modern society. Today, it is well established that LBPS affects not only functional status and work capacity but is also associated with numerous comorbidities, psychosocial consequences, and significant economic burdens on healthcare systems. Despite the abundance of publications, clinical guidelines, and therapeutic recommendations, substantial variability in diagnostic and therapeutic approaches persists in everyday clinical practice—particularly in the domain of conservative treatment and physiotherapeutic interventions.

The author wishes to express sincere and heartfelt gratitude to his family, and especially to his wife, Marina, MSc in Religious Studies, for her unwavering support, patience, and understanding throughout the prolonged process of writing this book. Her intellectual breadth, humanistic perspective, and capacity to situate scientific work within a broader existential and ethical framework were a constant source of encouragement and motivation.

Special and profound appreciation is extended to Nenad Končar, PhD, whose guidance, encouragement, and unequivocal motivation were instrumental in the decision to undertake and complete this work at this particular time. His conviction that knowledge and professional experience acquire true value only when articulated in written form and made accessible to others served as a decisive impetus at a moment when postponement would have been the easier option. It is fair to say that without his intellectual support and his clear message regarding the transience of time and the author's responsibility to share his expertise, this book, in its present form, would likely not exist.

The content of this book is designed to integrate foundational knowledge from anatomy, biomechanics, and the pathophysiology of the lumbar spine with the clinical application of multimodal therapy. Clear patient inclusion criteria, the methodology of the therapeutic intervention, and both objective and subjective outcome measures used in the evaluation of treatment effectiveness are presented. This approach was intended to ensure not only the scientific rigor of the study but also the practical applicability of the reported findings.

This book arose from the need for a systematic and objective presentation of the clinical outcomes of multimodal therapy in patients with lumbar pain syndrome and is thematically and methodologically grounded in research conducted as part of the author's doctoral dissertation. While the doctoral dissertation served as the foundation of the scientific investigation, this book represents an independent, cohesive, and substantively expanded work. Compared with the dissertation, the text is further enriched by more detailed clinical interpretation of the results, a broader theoretical framework, and a stronger emphasis on the applicability of the findings in everyday clinical practice.

The presented clinical study includes 210 patients, enabling statistically robust analysis of therapeutic effects and providing insight into changes in both subjective and objective clinical indicators under real-world clinical conditions. Particular emphasis is placed on the assessment of pain intensity, functional status, and activities of daily living, as these represent the most clinically relevant outcome measures.

This need provided the impetus for the present book. My goal was to integrate contemporary scientific evidence, clinical experience, and practical approaches to LBPS into a single, coherent volume, with particular emphasis on clearly structured, thoroughly described, and clinically applicable therapeutic protocols. As highlighted by the reviewers, a distinctive strength of this book lies in its systematic presentation of physiotherapy and rehabilitation interventions—a component of treatment that is often insufficiently detailed in the literature, despite being decisive for treatment outcomes in many cases.

The book is intended for physicians of various specialties (physical and rehabilitation medicine, orthopedics, neurology, radiology, and family medicine), physiotherapists, kinesiologists, students of health sciences, and all professionals who work with musculoskeletal pain. It is designed to guide the reader from anatomical and biomechanical foundations, through diagnostic algorithms and differential diagnostic considerations, to concrete therapeutic decisions and physiotherapy protocols, with an emphasis on rational, evidence-based clinical decision-making.

Throughout this process, I had the privilege of relying on the knowledge, experience, and personal support of outstanding experts who agreed to serve as reviewers.

Professor Ivan Drinković, MD, PhD, Primarius, owner and director of the Drinković Polyclinic in Zagreb, university professor, author of numerous scientific papers and books, and an internationally recognized radiologist, is a person with whom I have been professionally growing since May 14, 2014. Our long-standing collaboration has shaped my clinical approach, way of thinking, and the standard of quality to which I aspire. Professor Drinković consistently demonstrates a rare combination of high professional standards, openness to new knowledge, and genuine willingness to support younger scientists. When I asked him to review my book, his response — “of course, no problem” — was not merely an expression of goodwill, but also a confirmation of the trust he has shown me over the years. In his review, he particularly emphasized the importance of accurate and clearly interpreted radiological diagnostics in understanding LBPS, noting that the book effectively links clinical presentation with imaging findings and therapeutic decision-making. His comments contributed significantly to refining the diagnostic chapters and aligning the text with the real-world demands of modern radiology.

Vlatka Matić, MD, specialist in physical and rehabilitation medicine, currently work as Head of the Polyclinic and Consultative Health Care Department at the Special Hospital for Medical Rehabilitation Naftalan. Through her extensive daily clinical work with patients suffering from chronic pain and rheumatic diseases, she represents a core segment of contemporary rehabilitation practice. As a highly dedicated, conscientious, and practically oriented physician, Dr. Matić demonstrates a precise understanding of the existing gaps in the professional literature, as well as a clear awareness of what is genuinely applicable in everyday clinical settings. In her review, she emphasized as a particular strength of the book its comprehensive and systematic presentation of all key therapeutic procedures. Importantly, the text does not remain at the level of broad or generic recommendations, but instead offers detailed, clinically grounded descriptions of physiotherapeutic interventions specifically tailored to lumbar back pain syndrome (LBPS). In her assessment, this level of specificity and practical orientation makes the book an exceptionally valuable resource for physiatrists and physiotherapists, especially those in the early stages of their professional careers, as it enables the direct translation of theoretical knowledge into patient care. Her insightful comments and constructive suggestions further encouraged the expansion of detailed procedural descriptions, clinical decision-making algorithms, and concrete practice-oriented recommendations within the book.

Professor Boro Nogalo, MD, PhD, is a distinguished specialist in pediatric pulmonology with an academic and clinical career spanning more than three decades. He served for many years as Director of the Children's Hospital Srebrnjak, an institution widely recognized for its clinical excellence and scientific contribution. In his review, Professor Nogalo particularly highlighted the breadth of the book's conceptual framework and the clarity and consistency of its argumentation. Drawing on his extensive experience as a clinician, scientist, and healthcare leader, he noted that the book successfully transcends narrow disciplinary boundaries and opens an important perspective on LBPS as a condition that may manifest as early as childhood and adolescence. He emphasized that this broader view significantly enriches current understanding of musculoskeletal pain syndromes across the lifespan. His positive evaluation, together with his recognition of the

author's scientific ambition, represents a strong source of professional encouragement. Professor Nogalo further underlined that works of this nature contribute meaningfully to the development of a culture of responsible, evidence-based, and professionally grounded approaches to musculoskeletal pain, including lumbar pain syndrome (LBS), and that they play an important role in the education of future generations of physicians and other healthcare professionals.

Professor Vjieran Nikolić Heitzler, MD, PhD, Primarius, is an eminent specialist in internal medicine and subspecialist in cardiology, as well as a professor at the Faculty of Medicine, University of Zagreb. He worked for many years as Head of the Coronary Care Unit at the Clinical Hospital Center "Sestre milosrdnice". In his review, Professor Nikolić Heitzler provided a highly valuable interdisciplinary perspective, emphasizing that LBPS represents a global health problem with consequences that extend beyond impaired locomotor function. He strongly agreed with the book's conceptual premise that LBPS has broader implications for overall and cardiovascular health. In particular, he highlighted the importance of recognizing the complex interrelationship between chronic pain, reduced physical activity, metabolic alterations, and increased cardiovascular risk, especially in patients with significant neurological deficits and limited spinal mobility. His assessment that the book addresses an inherently complex and multifaceted topic serves not only as a personal expression of support, but also as a professional validation of the need to approach LBPS within a broader systemic and integrative health framework. The proposed connections between musculoskeletal and cardiovascular systems further reinforced the motivation to emphasize the global health status of patients throughout the text.

Katarina Dujmović Hasanbegović, MD, a specialist in dermatology and venereology, with more than 20 years of work experience in medicine. She completed her specialization at the Clinic for Dermatology and Venereology of the Clinical Center of the University of Sarajevo and is currently employed at the Clinic for Dermatology of the Clinical Hospital Center Rijeka. She also serves as a assistant at the Department of Dermatovenereology of the Faculty of Medicine, University of Rijeka, and actively participates in numerous national and international scientific congresses. In her review of the book, Dr. Dujmović

Hasanbegović emphasized the high professional and medical standard of the text. She highlighted that the topic is addressed comprehensively and systematically, reflecting a solid scientific foundation and a clear understanding of contemporary clinical practice. Particular value was attributed to the clarity and accessibility of the content, which, despite its academic rigor, remains understandable to a wider audience. In her opinion, the book successfully combines scientific precision with practical applicability, making it a high-quality and relevant contribution to medical literature, especially in view of the growing global prevalence of lumbar pain syndrome.

PhD, Pavo Perković, MD, is a specialist in gynecology and obstetrics and a subspecialist in gynecological oncology, with more than 25 years of extensive clinical experience. He currently serves as the Head of the Clinic for Women's Diseases and Obstetrics at the Merkur Clinical Hospital and is widely recognized as a leading expert who continuously follows the latest scientific and clinical advancements. In his evaluation, PhD Perković expressed a particularly positive impression of the professional and medically precise manner in which physiotherapy procedures are presented. He noted that lumbar pain syndrome represents one of the most significant health problems of modern society and emphasized that the book addresses this issue in a comprehensive and clinically meaningful way. He especially appreciated the clear presentation of the patient's pathway, from initial presentation to therapeutic decision-making, with a strong focus on physical therapy as a fundamental treatment modality. In his assessment, the book represents a valuable and reliable resource that will enable patients to better understand their diagnosis and available treatment options, while also serving as a useful reference for clinical practice.

PhD, Maja Crnogorac, MD, is a specialist in clinical radiology, currently employed at the Drinković Polyclinic in Zagreb, with prior long-term experience at Dubrava Clinical Hospital. She regularly participates in international scientific symposia and congresses and is actively engaged in professional development within her field. In her review, Dr. Crnogorac highlighted that book provides a thorough and professionally structured overview of therapeutic procedures for the treatment of lumbar pain syndrome. She particularly emphasized the chapter dedicated to kinesitherapy and therapeutic exercises,

noting that the exercises are described clearly, professionally, and supported by illustrative images that facilitate correct understanding and execution. She pointed out that improper exercise performance is a frequent cause of symptom exacerbation and that this book effectively addresses that issue. Furthermore, she appreciated the concise and focused structure of the chapters, as well as the author's decision to avoid unnecessary repetition of well-known spinal anatomy, instead concentrating on physical therapy interventions. In her opinion, this approach makes the book a highly practical and medically sound resource for both healthcare professionals and patients.

Professor Daniela Malnar, MD, PhD, Dean of the Faculty of Health Studies in Rijeka, internationally recognized scientist and author of numerous scientific articles and books, including an anatomy textbook, holds a particularly important place in this endeavor. She was my mentor during my doctoral studies, and her professional and personal approach has profoundly influenced my academic development. During my studies, she demonstrated exceptional rigor regarding scientific accuracy and methodological standards, while simultaneously offering strong support and understanding for the challenges faced by doctoral students. She was pleasantly surprised by my examination performance at the School of Medicine, and the fact that she likely did not expect me to write a book relatively soon makes her current support all the more meaningful. In her review, she emphasized the importance of clear structure, terminological consistency, and the integration of theoretical concepts with practical implications, and on multiple occasions contributed to shaping the text accordingly through her advice. Her willingness, even today as a dean and active scientist, to devote time to consultation, feedback, and guidance is invaluable to me.

The positive reviews provided by these distinguished experts are not merely a personal recognition, but also a confirmation that this book has genuine practical and scientific value. At the same time, they represent an obligation—a reminder that medicine is a dynamic science and that in the field of LBPS, as in all others, there are no final answers. Each new study, each new clinical insight, and each new generation of physicians and therapists will require further refinement and expansion of existing knowledge.

I do not view this book as the final word on low back pain syndrome, but rather as a solid foundation upon which new research, clinical guidelines, and educational programs can be built. If it helps clinicians make even one better, more evidence-based therapeutic decision in daily practice; if it encourages at least one professional to reflect more deeply on the patient with LBPS, their comorbidities, and quality of life; and if it serves as a clear and reliable reference for even one generation of students and young colleagues, then the purpose of this book will have been fulfilled.

I am deeply grateful to all reviewers for their time, expertise, and candor, as well as for their continuous personal support. Their confidence in this project served as both an important corrective and a powerful incentive to ensure that the book was written as precisely, responsibly, and practically as possible. The pages that follow are the result of a shared effort to present the complexity of low back pain syndrome in a clear, systematic, and scientifically grounded manner—for the benefit of our patients and all those committed to providing them with the highest standard of care.

This book is dedicated to you.

Your dedication to understanding, exploring, and advancing human knowledge continues to inspire us every day. May this work serve as a guiding light throughout your professional and educational journey — helping you grasp complex clinical processes, make informed decisions, and confidently pursue new scientific and therapeutic horizons.

Throughout the history of medicine, few areas have influenced quality of life as profoundly as the treatment and rehabilitation of low back pain. Lumbar pain syndrome remains one of the most widespread health challenges of our time, and its effective management continues to demand insight, precision, and compassion from all healthcare professionals. It is within this context that “Rehabilitation for Low Back Pain: Clinical Study on 210 Patients” emerges as a valuable resource for anyone seeking to deepen their understanding and enhance their clinical practice.

This book explores the intricate interplay of anatomical, biomechanical, and biopsychosocial factors that shape the course and outcome of lumbar pain. Through a systematic analysis of therapeutic methods, functional assessments, and findings from an extensive clinical study, readers gain a comprehensive view of contemporary rehabilitation principles and the most effective approaches for improving patient functionality and quality of life.

As you progress through the chapters, prepare to be enriched and empowered. This book is not only a guide to rehabilitation; it is an invitation to practice medicine thoughtfully, sustainably, and with scientific integrity — an approach that blends expertise with empathy and encourages collaboration across disciplines. In the pursuit of knowledge, let us move forward together: embracing challenges, celebrating new discoveries, and never ceasing to marvel at the complexity and resilience of the human body.

Welcome to a new chapter in rehabilitation medicine.

Welcome to a journey that restores movement, function, and hope.

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Introduction

The rapid advancement of medical science—particularly within the field of musculoskeletal medicine and rehabilitation—has brought about a paradigm shift in the understanding, diagnosis, and treatment of lower back pain syndromes. In an era where clinical practice increasingly integrates biomechanical, neurophysiological, and biopsychosocial models, understanding the interplay among these factors has become more essential than ever. This book aims to provide a comprehensive overview of contemporary scientific knowledge and clinical approaches to Lumbar Pain Syndrome (LPS), offering practitioners a thorough and practically applicable foundation for work in this challenging field.

The integration of new diagnostic tools, advanced rehabilitation techniques, and personalized therapeutic protocols is not merely a passing trend but an evolution that fundamentally reshapes the boundaries of what is possible in clinical care. From more precise functional assessment systems and targeted kinesiotherapy to multidisciplinary rehabilitation strategies and psychological interventions aimed at reducing chronic pain, today's approaches reflect a practice in which traditional methods are enhanced—and often surpassed—by modern, evidence-based strategies.

This book represents the culmination of many years of professional experience and research by its authors, who, drawing from various domains—physical medicine, kinesiotherapy, rehabilitation, and health sciences—provide a comprehensive perspective on the complex etiology and management of LPS. By combining theoretical principles with practical guidelines, the text equips readers with knowledge that can be readily applied to everyday clinical practice.

Throughout the chapters, you will explore the essential anatomical and biomechanical characteristics of the lumbar spine, the prevalence and public-health significance of LPS, diagnostic and classification models, and contemporary therapeutic approaches, including findings from an extensive clinical study involving 210 patients. Real-world examples, clinically validated diagnostic algorithms, and structured treatment guidelines are presented to ensure that the reader develops a solid understanding not only of the theoretical framework but also of the clinical reasoning that underlies effective decision-making.

As you progress through this work, you will discover how timely and targeted intervention can prevent the chronification of symptoms, how patient education and active participation shape the recovery process, and how an interdisciplinary approach—based on collaboration among

physiotherapists, physicians, psychologists, and other health professionals—constitutes the most effective model for managing one of the most widespread pain syndromes of the modern era.

Ultimately, this book is not merely a review of existing literature but an invitation to adopt a modern, evidence-based, and comprehensive approach to Lumbar Pain Syndrome. By implementing these principles, clinicians can achieve higher levels of patient functionality, promote greater independence, and significantly reduce both the personal and societal burden associated with this pervasive clinical condition.

Importance and Prevalence of Lumbar Pain Syndrome

Lumbar Pain Syndrome (LPS) is a term that refers to a broad spectrum of clinical conditions characterized by pain, stiffness, reduced mobility, and sometimes muscular weakness in the lower back, specifically within the lumbar region of the spine. The underlying causes of LPS are diverse, including degenerative disc disease, facet joint osteoarthritis, muscular or ligamentous strains, herniation or protrusion of intervertebral discs, and nerve root compression or irritation. Due to its high frequency and tendency to recur, LPS stands as a major public health concern, with profound effects on individuals, employers, and society at large.

Statistics from the World Health Organization (WHO) and numerous epidemiological studies confirm the extremely high prevalence of low back pain: it is estimated that 60% to 80% of adults will experience at least one episode of lumbar pain during their lives. For approximately one-quarter of those affected, symptoms may recur repeatedly or progress to a chronic state, posing significant challenges for effective treatment and rehabilitation. Among the working-age population, low back pain is the most frequent cause of absenteeism and work-related disability, while in older adults, it is a leading cause of limited mobility and dependency on others for daily activities.

The economic impact of LPS cannot be overstated. Each year, millions of individuals seek medical care for lower back pain, leading to vast expenditures on diagnostic imaging (X-ray, MRI, EMG), specialist consultations, physical therapy, pharmacological treatments, and in a minority of cases, surgical interventions. Beyond direct healthcare costs, lumbar pain syndromes impose indirect costs by diminishing personal productivity, reducing participation in family and social life, and decreasing overall quality of life for patients and their families.

It is crucial to recognize that not only somatic (physiological) but also psychosocial factors contribute significantly to the development, course, and outcome of LPS. Prolonged stress, anxiety, symptoms of depression, low levels of physical activity, poor ergonomic conditions in the workplace, and general dissatisfaction with work all heighten the risk of persistent or recurring back pain. Chronic low back pain is often comorbid with other chronic non-communicable diseases, and patients are at increased risk for developing chronic pain syndromes, dependence on analgesics, and social isolation.

Given the multifactorial and complex nature of LPS, modern management and prevention approaches require a collaborative, multidisciplinary effort—bringing together primary care physicians, physiatrists, physiotherapists, psychologists, and occupational therapists, with each patient's care plan tailored to their unique needs. Emphasis is placed on early intervention, comprehensive patient education, the adoption of healthy lifestyle habits, and the prevention of chronicity. Such strategies are essential to reducing both the individual and societal burden of lumbar pain syndrome, ultimately supporting a return to optimal functionality and quality of life.

Book Objectives

Given the extremely high prevalence, significant public health impact, and multifactorial etiology of Lumbar Pain Syndrome (LPS), there is a continuous demand for a publication that consolidates up-to-date scientific evidence with clinical experience, making it accessible and practically useful for a broad range of healthcare professionals. The field of low back pain is dynamic, with constant advancements in diagnostic technologies, rehabilitation strategies, and therapeutic interventions, all necessitating ongoing education and adaptation of clinical guidelines.

The objectives of this book are multifaceted and clearly articulated:

- To provide a systematic review of the fundamental anatomical, biomechanical, and pathophysiological features of the lumbar spine: By exploring the relevant anatomical structures, functional biomechanics, and biological mechanisms underlying the onset and persistence of pain, the book enables the reader to develop a thorough understanding of the causes and progression of LPS.
- To present the latest and most reliable methods of diagnosis and classification for lower back pain: The book offers a comprehensive description of clinical assessments, validated

functional questionnaires, and imaging techniques (X-ray, MRI, EMG), as well as their application in daily practice. Special attention is given to the importance of differential diagnosis to avoid mismanagement.

- To analyze and evaluate the effectiveness of physiotherapy and kinesiotherapy interventions: Drawing on the results of an extensive clinical study involving 210 patients, the book presents and interprets the outcomes of contemporary therapeutic approaches, discussing their advantages, limitations, and the long-term effects on pain relief, functional recovery, and quality of life.
- To promote the integration of scientific evidence into clinical practice: The goal is to encourage practitioners to base their therapeutic decisions on the latest research findings, ensuring individualized care that considers all bio-psycho-social aspects of the condition.
- To raise awareness of the importance of an active, multidisciplinary, and personalized rehabilitation strategy: The book emphasizes the patient's active participation in recovery, the need for ongoing education and prevention of recurrence, and the significance of teamwork among professionals from various medical and health-related disciplines.

This book is intended for a wide professional audience, including physiotherapists, specialists in physical medicine and rehabilitation, general practitioners, students of physiotherapy, kinesiology, and medicine, as well as researchers and scientists in the health sciences. Its special value lies in serving as an educational manual and a reference for daily practice for all professionals involved in the diagnosis, treatment, and prevention of musculoskeletal disorders. Additionally, the book provides a strong foundation for the development of new clinical guidelines, protocols, and scientific research in the field.

Concluding Note

Ultimately, this book is not merely a review of existing literature, but also an invitation to embrace a modern, evidence-based, and comprehensive approach to lumbar pain syndrome. By applying these principles, it is possible to achieve a higher level of functionality, greater patient independence, and a substantial reduction in both the personal and societal burden associated with this pervasive clinical condition.

Short Executive Summary

Levels of lower back pain

Pain Levels
1. Mild pain (low to moderate)
2. Moderate pain
3. Severe pain
Scales used
- Visual Analogue Scale (VAS)
- Oswestry Disability Index (ODI) for disability/functionality
- Roland-Morris Disability Questionnaire (RMDQ)

Available Treatments

Physical Therapies:
- High-Intensity Laser Therapy (HILT)
- Pulsed Electromagnetic Field Therapy (PEMF)
- Transcutaneous Electrical Nerve Stimulation (TENS)
- Interferential Current (IFC)
- Therapeutic Ultrasound

- Massage and Manual Therapies
- Kinesiotherapy (targeted exercises)
- Cryotherapy
- Acupuncture
Pharmacological Treatments:
- NSAIDs (e.g., naproxen)
- Oral steroids (short-term for radiculopathy)
Surgical interventions:
- Indications for disc herniation and vertebrogenic pain

Possible Causes of Lower Back Pain

- Non-specific low back pain
- Discogenic pain (disc degeneration)
- Disc herniation (protrusion, prolapse, extrusion)
- Vertebrogenic pain (vertebral body pathology)
- Sacroiliac joint dysfunction
- Myofascial pain
- Musculoskeletal and ligament injuries
- Neurological causes (radiculopathy, nerve compression)
- Vertebral fractures in elderly patients
- Congenital malformations of the spine

Recommended treatment mix depending on pain level, cause, duration & intervals

Acute phase:
- Exercising is counter-indicated / forbidden
Mild to moderate pain, non-specific low back pain:
- Kinesiotherapy (targeted exercises) 3x/week, 6–8 weeks
- TENS or interferential current daily or every other day
- PEMF or HILT 3-4 times/week, 4–6 weeks
- Massage/manual therapy 1-2 times/week
- Ultrasound therapy 2-3 times/week
- Pharmacotherapy as needed (NSAIDs)
Severe pain, discogenic or neurological complications:
- Above physical therapies + stricter monitoring
- Short-term oral steroids for radiculopathy
- Surgical evaluation if no improvement after 6–8 weeks
- Intensive multidisciplinary rehabilitation

Intervals and duration:
- Initial intensive therapy phase for 4–6 weeks
- Maintenance and prevention with exercises 1-2x/week
- Regular check-ups every 4–6 weeks

1

Anatomy of the Spine

1.1 Structure of the Spine

The spine (columna vertebralis) is a key anatomical and functional axis of the human body, providing stability, flexibility, and protection for vital neurological structures. It extends from the base of the skull to the coccyx and accounts for approximately 40% of the total body height of an adult. The spine is not merely a passive structural column but a dynamic system that enables bending, rotation, lateral flexion, and the absorption of external forces during walking, sitting, lifting, and other movements.

Anatomical Regions and Division of Vertebrae

The spine consists of 33 to 34 vertebrae, organized into five well-defined anatomical sections:

- **Cervical Spine (C1–C7):** The most mobile part of the spine, allowing movements of the head such as flexion, extension, and rotation. The first cervical vertebra (atlas) and the second (axis) have a unique structure adapted to supporting the skull and enabling rotation.
- **Thoracic Spine (T1–T12):** Connected to the ribs and sternum, it plays a role in protecting vital organs (heart, lungs) and stabilizing the torso.
- **Lumbar Spine (L1–L5):** Composed of the largest vertebrae, which bear the greatest share of body weight and mechanical load. The lumbar region has limited rotation but allows significant flexion and extension.
- **Sacral Spine (os sacrum):** Formed by five fused vertebrae, creating a triangular bone that transfers body weight to the pelvic bones.

- Coccygeal Spine (os coccygis): Four to five fused vertebrae forming the final segment of the spine, considered a vestigial tail structure in humans.

The structure of the segments of the spine

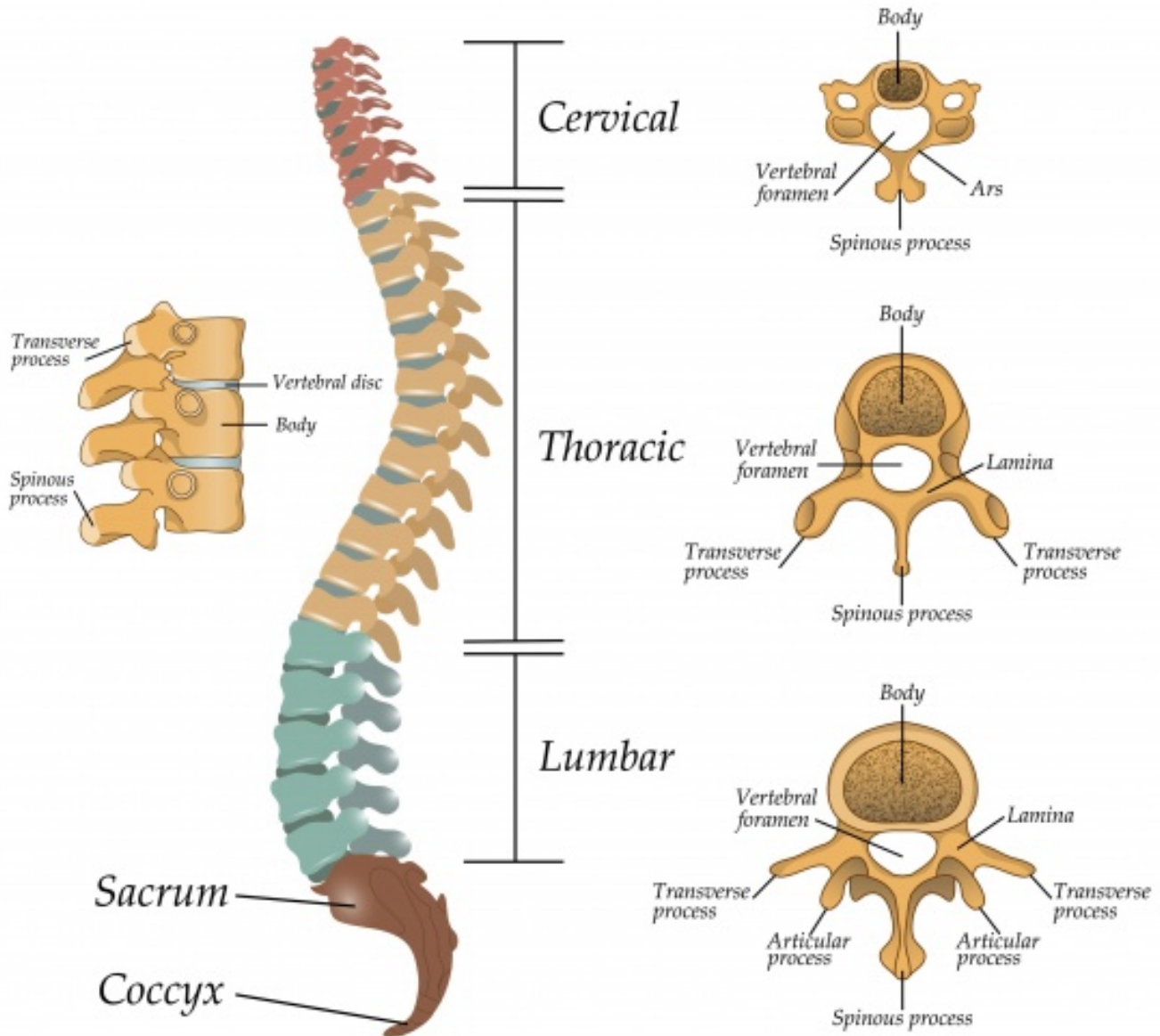


Figure 1. Segments of the Spine

Structural Elements of Each Vertebra

- Vertebral Body (corpus vertebrae): The main weight-bearing structure, composed of cancellous bone that absorbs shock.
- Vertebral Arch (arcus vertebrae): Closes the posterior portion of the vertebral canal and protects the spinal cord.
- Processes (processus spinosus, transversus, articularis): Serve as points of origin and attachment for numerous muscles, tendons, and ligaments, enabling fine motor control and stability.
- Vertebral Foramen (foramen vertebrale): The space within the vertebra through which the spinal cord, nerve roots, and blood vessels pass.

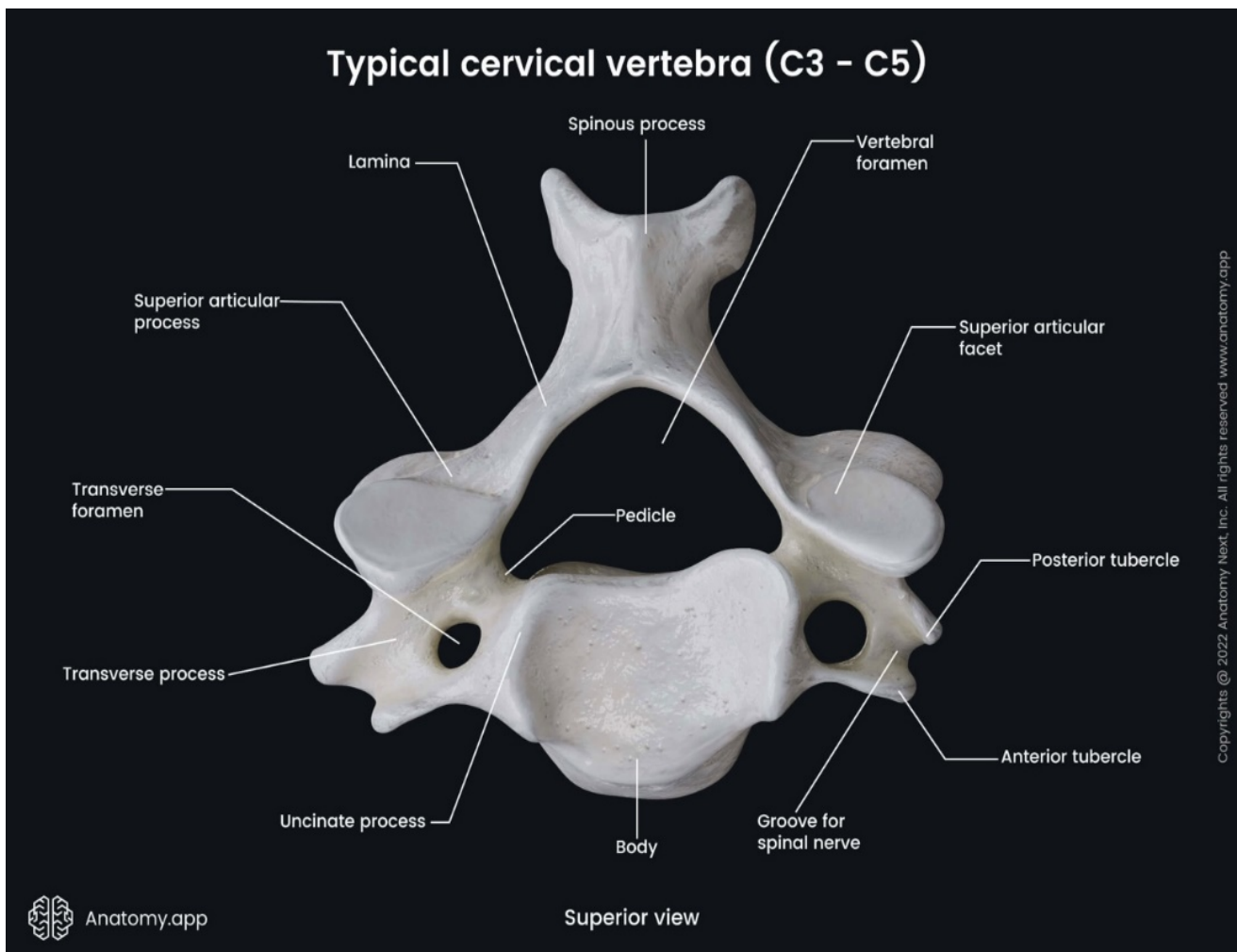


Figure 2. Main Structures of Vertebrae C3–C5

Lumbar Region of the Spine

The lumbar region consists of five lumbar vertebrae — vertebrae lumbales. A lumbar vertebra, like any typical vertebra, consists of the vertebral body (corpus vertebrae) and the vertebral arch (arcus vertebrae), which extends from the dorsal surface of the vertebral body.

The arch carries two transverse processes (processus transversi), a dorsally oriented spinous process (processus spinosus), and two superior and inferior articular processes (processus articulares superiores et inferiores). The vertebral body and arch together form the vertebral foramen (foramen vertebrale), which contains the spinal cord and its membranes.

The superior and inferior borders of the vertebral arch feature notches (incisura vertebralis superior et inferior). These notches, together with those of adjacent vertebrae, form the lateral openings (foramina intervertebralia). The lumbar vertebral body is large and transversely oval. The transverse process of a lumbar vertebra represents a rudimentary rib. Posteromedially lie the superior articular facets, while the inferior facets face anterolaterally. The spinous process is flattened laterally, nearly horizontal, and directed posteriorly.

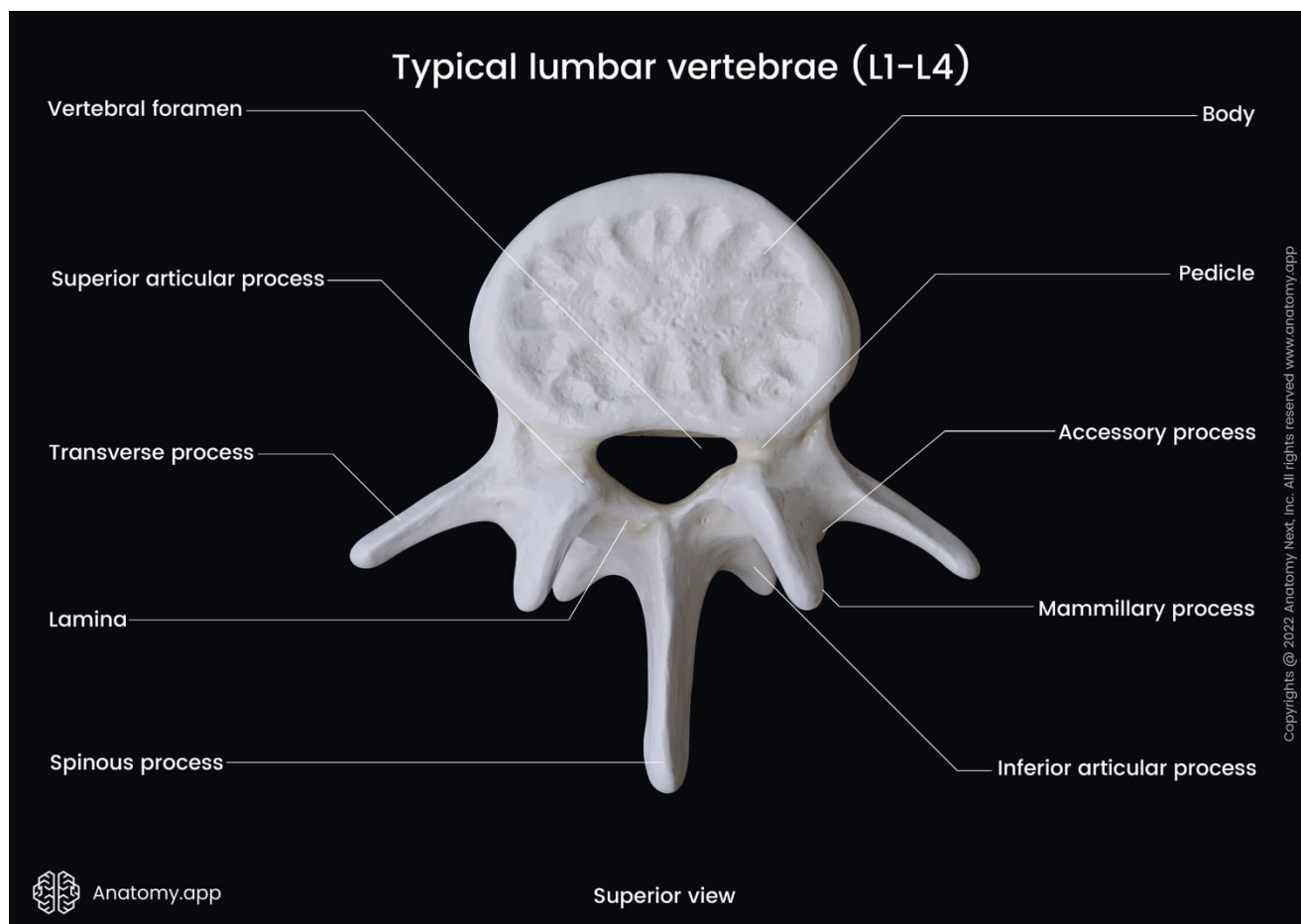


Figure 3. Lumbar Vertebra

Lumbar vertebrae are interconnected via syndesmoses (ligaments), synchondroses (intervertebral discs), and joints (artt. zygoapophysiales).

1. **Ligaments:** The anterior and posterior aspects of the vertebral bodies are connected by the anterior and posterior longitudinal ligaments (ligamenta longitudinale anterius et posterius). Adjacent transverse processes are connected by intertransverse ligaments (ligamenta intertransversaria), Spinous processes by interspinous ligaments (ligamenta interspinalia), And the tips of the spinous processes by the supraspinous ligament (ligamentum supraspinale). The ligamenta flava, composed mainly of elastic fibers, connect the vertebral arches.
2. **Intervertebral Discs:** Intervertebral discs act as shock absorbers between vertebrae and resemble flattened “cushions.” Each disc consists of: Annulus fibrosus — a strong outer lamellar ring, Nucleus pulposus — a soft, gelatinous central core.
3. **Facet Joints:** The superior articular processes of one vertebra articulate with the inferior articular processes of the vertebra above to form the zygapophyseal joints (artt. zygoapophysiales). The articular surfaces of lumbar vertebrae are oriented almost sagittally, limiting rotation and lateral flexion, while permitting extensive flexion and extension.

In most cases, spinal movements are limited by the joints, intervertebral discs, and ligaments. To allow mobility, the spine relies on the coordinated action of extensor and flexor muscles.

Intervertebral discs (disci intervertebrales) lie between adjacent vertebral bodies and consist of the fibrous ring (annulus fibrosus) and the inner gelatinous nucleus (nucleus pulposus). The discs provide elasticity, shock absorption, and even distribution of loads during movement. With aging, discs lose elasticity, which may lead to degenerative changes and the development of pain syndromes.

In addition to bony and cartilaginous elements, the spine is stabilized and mobilized by a complex system of ligaments (anterior and posterior longitudinal ligaments, interspinous and supraspinous ligaments, ligamentum flavum) and muscles (deep back muscles, abdominal muscles, pelvic muscles). This integrated structure allows the spine to balance stability and mobility, protect the spinal cord, and maintain upright posture.

Understanding the complex anatomy of the spine is essential for proper diagnosis, treatment, and prevention of locomotor system disorders.

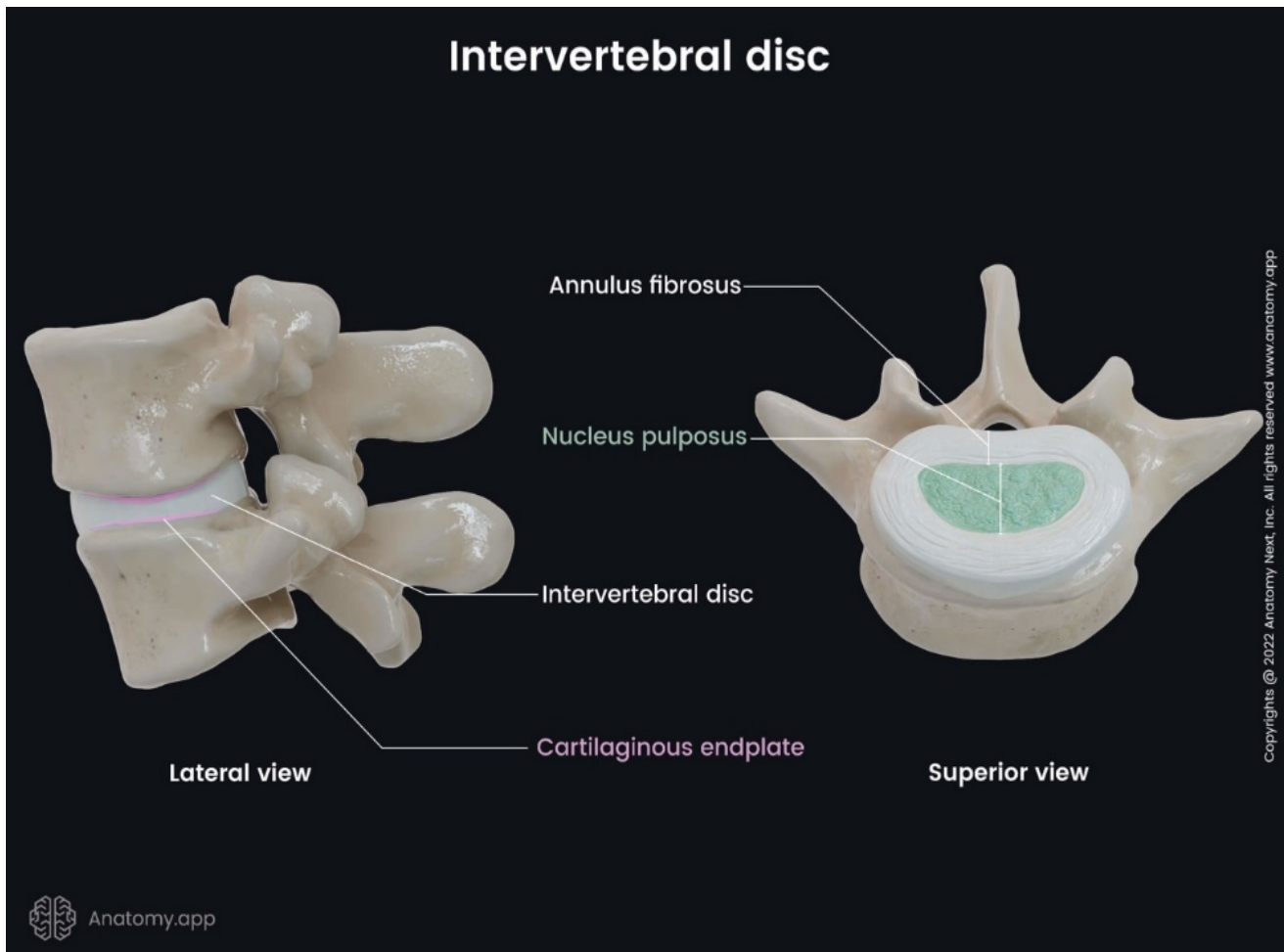


Figure 4. Intervertebral Disc

1.2 Lumbar and Lumbosacral Regions

The lumbar region of the spine is situated between the thoracic vertebrae above and the sacrum below, comprising five robust vertebrae, designated L1 through L5. This segment is anatomically and functionally critical, as it bears the brunt of upper body weight and transmits mechanical loads to the pelvis and lower extremities. The lumbar vertebrae are the largest and strongest of the spinal column, uniquely designed to endure powerful compressive and shearing forces encountered during daily activities such as lifting, bending, twisting, and prolonged sitting.

The lumbosacral junction—the interface between the fifth lumbar vertebra (L5) and the sacrum (S1)—represents one of the most biomechanically demanding zones of the spine. This area provides necessary flexibility for trunk movement but is also the most susceptible to degenerative changes and injuries such as disc protrusion or herniation. The L5–S1 intervertebral disc is the most frequently affected by degenerative processes, often leading to significant clinical symptoms, including localized back pain and neurological disturbances.

The stability and functionality of the lumbar and lumbosacral regions depend on an intricate interplay between bony architecture, facet joints, musculature, ligaments, and fascial layers. The region is traversed by critical neural elements—spinal nerve roots forming the lumbar and sacral plexuses. The most prominent of these is the sciatic nerve (nervus ischiadicus), the largest and longest nerve in the human body. Compression or irritation of the nerve roots, due to disc herniation, spinal stenosis, or spondylolisthesis, typically manifests as radiculopathy: pain, numbness, weakness, and tingling radiating from the lower back through the gluteal area and down the posterior aspect of the thigh and leg, sometimes reaching the foot—a classic presentation of sciatica.



Figure 5. View of the Lumbosacral Junction

Biomechanical Importance:

The lumbosacral angle and the orientation of the pelvis (anterior or posterior pelvic tilt) have a profound impact on the distribution of mechanical loads across the spine. Abnormalities such as hyperlordosis, flattening of the lumbar curve, or pelvic dysfunction can lead to maladaptive loading patterns, chronic pain, reduced mobility, and the development of muscular and ligamentous imbalances. The condition of the lumbosacral region directly influences overall posture, gait biomechanics, and the functional capacity of the lower limbs.

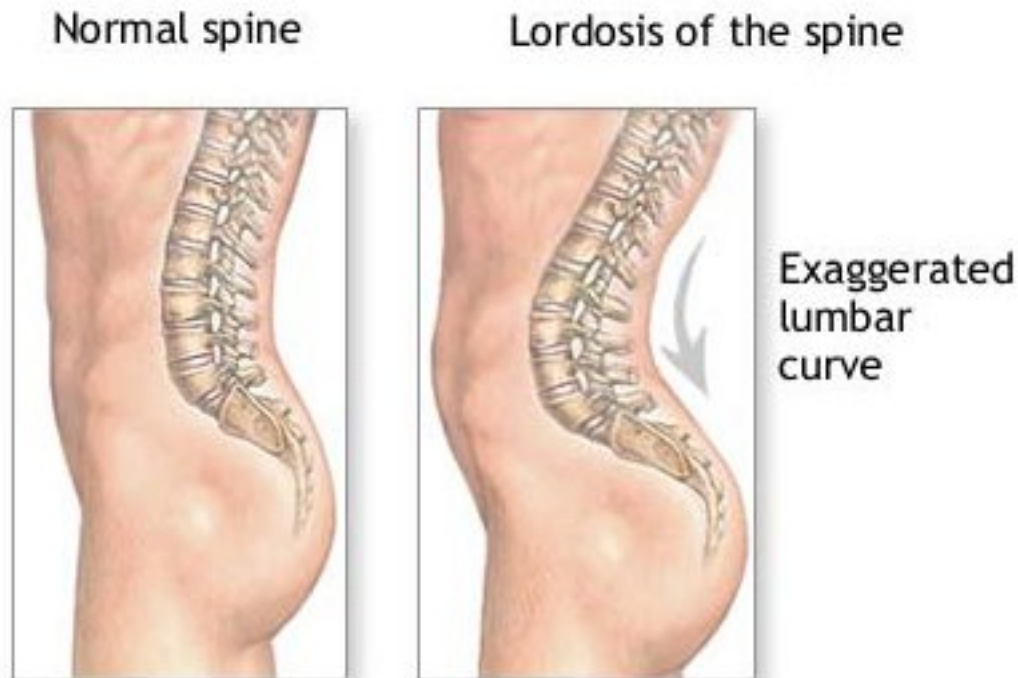


Figure 6. Representation of Lumbar Lordosis

Beyond mechanical and degenerative etiologies, factors such as inflammation, metabolic disturbances, vascular compromise, and psychosocial stressors can all contribute to pain syndromes in this area. For this reason, comprehensive assessment and management of lumbar and lumbosacral pain require an interdisciplinary approach—incorporating clinical evaluation, imaging, physical therapy, exercise regimens, and patient education—to achieve optimal outcomes and prevent chronic disability.

1.3 Supporting Muscles and Ligaments of the Spine

The muscular and ligamentous support of the spine forms a fundamental component of postural stability, movement control, and protection of neurological structures. The muscles involved in spinal stabilization can be divided into deep (local) and superficial (global) groups, each with a specific role in the biomechanics of the vertebral column.

The deep (local) spinal muscles, such as the m. multifidus and m. transversus abdominis, are located directly adjacent to the vertebrae and intervertebral joints. The multifidus muscle is essential for segmental stability, fine motor control, and maintaining the spine in a neutral position. The transversus abdominis, the deepest layer of the abdominal musculature, acts as a natural corset around the lumbar spine, creating intra-abdominal pressure and reducing load on the intervertebral discs. Activation of these muscles is crucial for preventing recurrence of lumbar pain and improving neuromuscular control.

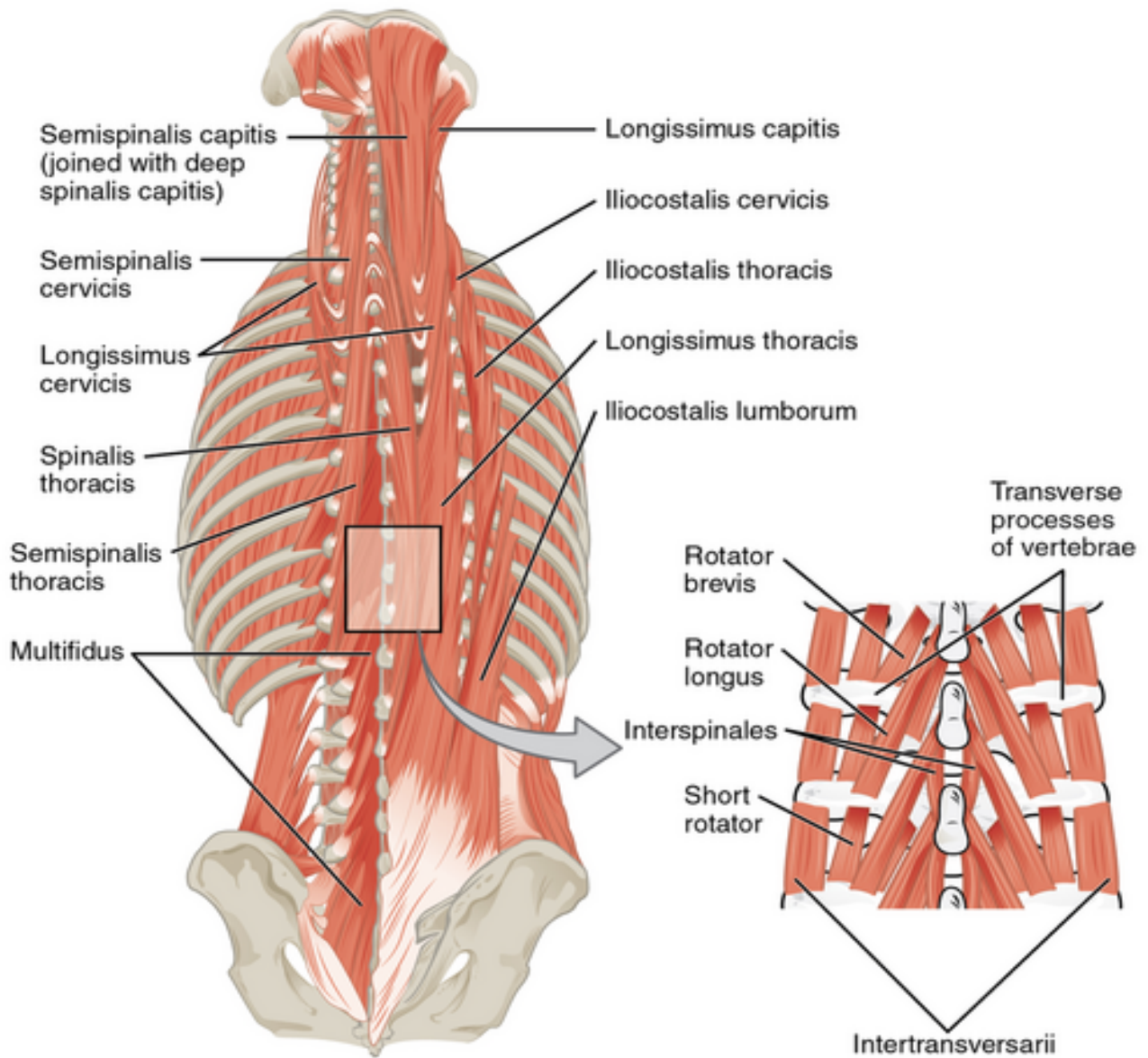


Figure 7. Multifidus Muscle

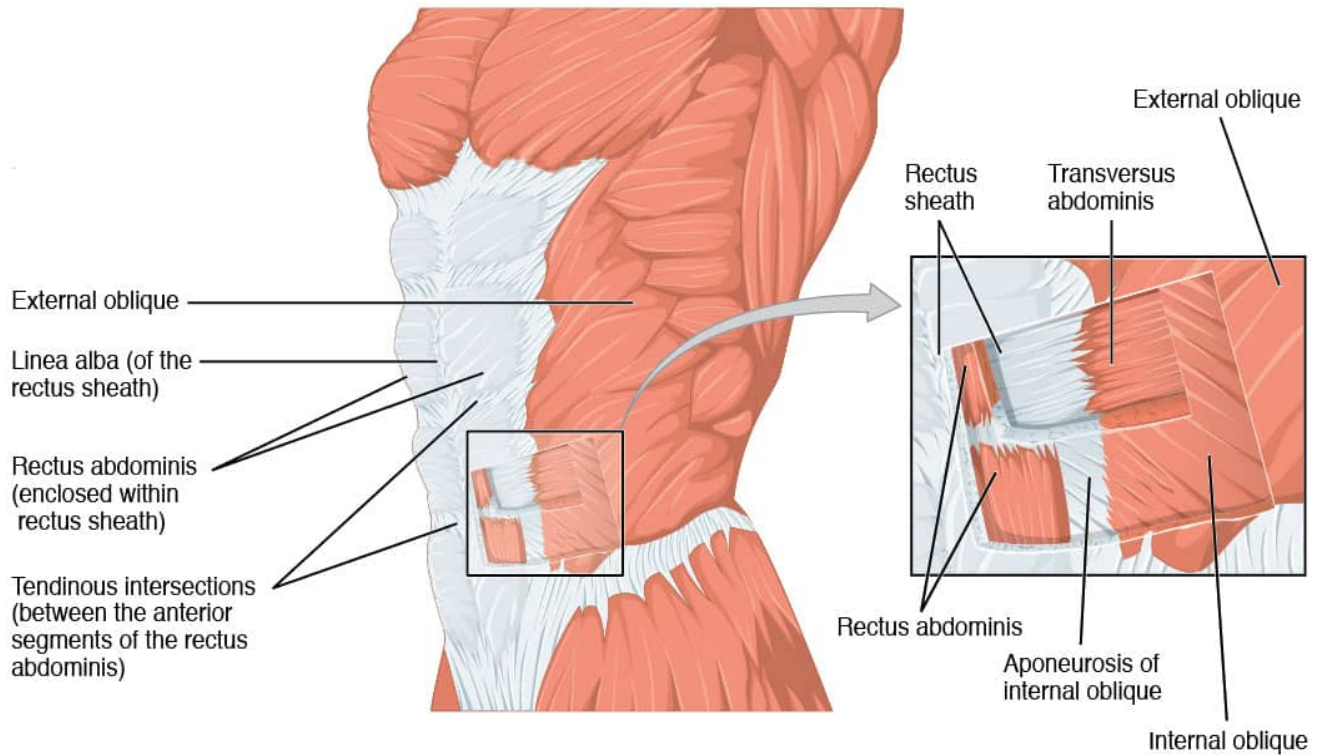


Figure 8. Transversus Abdominis Muscle

The superficial (global) muscles, such as m. erector spinae, m. latissimus dorsi, and m. obliquus externus abdominis, contribute to large-scale trunk movements, enabling extension, lateral flexion, and rotation of the spine, as well as helping maintain an upright posture. The erector spinae, the longest and strongest muscle group of the posterior trunk, is vital for lifting the body from a forward-bent position and absorbing forces during walking, running, or lifting loads.

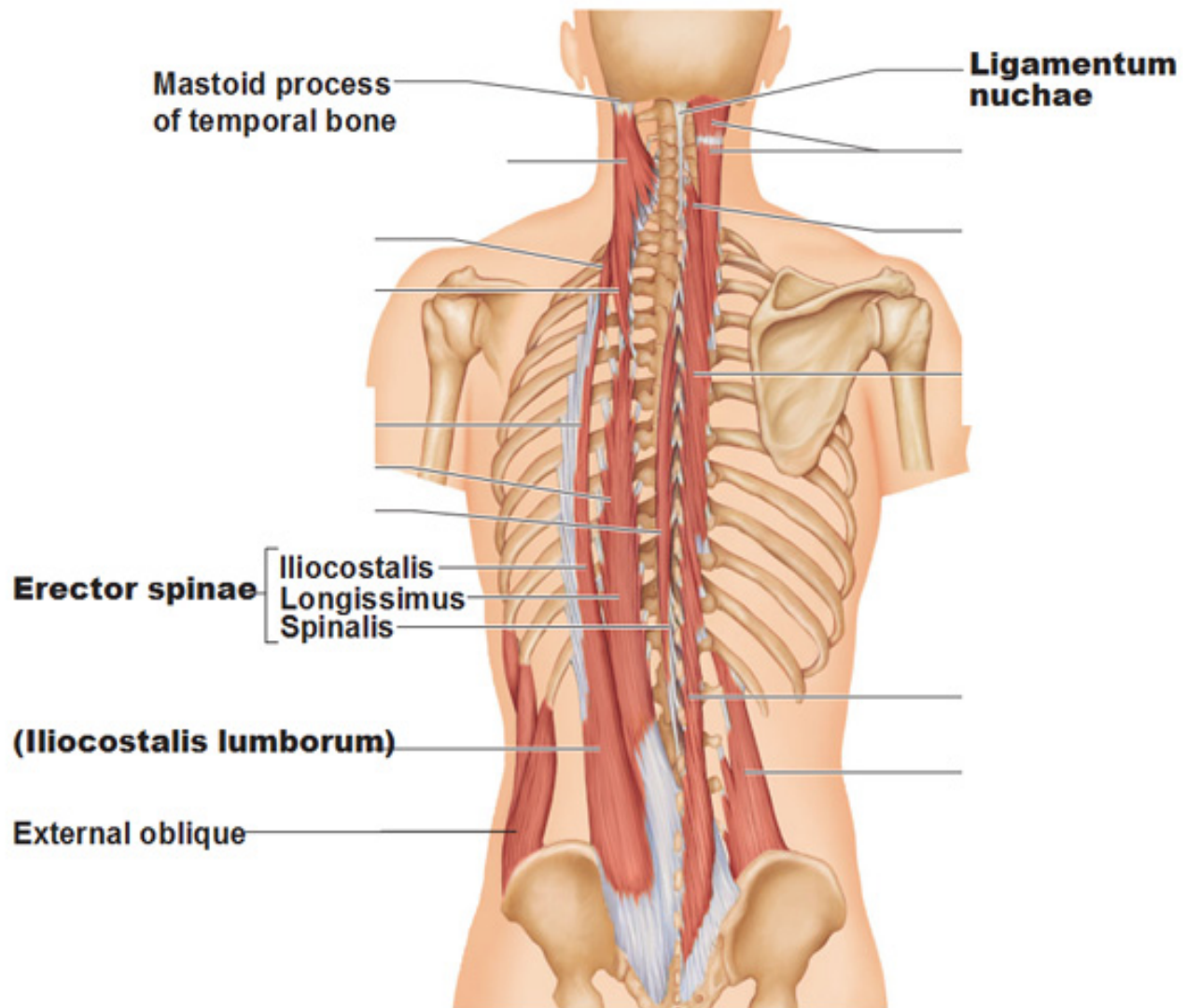


Figure 9. Erector Spinae Muscle Group

In individuals with chronic lumbar pain, weakness, inhibition, or atrophy of the deep stabilizing muscles is frequently present, leading to overloading of the superficial muscles and the development of muscular imbalances. This results in impaired neuromuscular control, poor posture, reduced functionality, and an increased risk of recurrent injuries.

The spinal ligaments provide passive stability to the vertebral column, limit excessive movements, and protect joints and nerves from mechanical injury. The most important ligaments include:

- Ligamentum longitudinale anterius and posterius – extend along the entire anterior and posterior surfaces of the vertebral bodies, stabilizing the spine and preventing excessive flexion/extension.
- Ligamentum flavum – a yellow elastic ligament connecting the inner surfaces of the vertebral arches, helping maintain elasticity and assisting in returning to a neutral position after bending.
- Ligamenta interspinalia and supraspinalia – connect adjacent spinous processes, additionally limiting flexion and rotation.

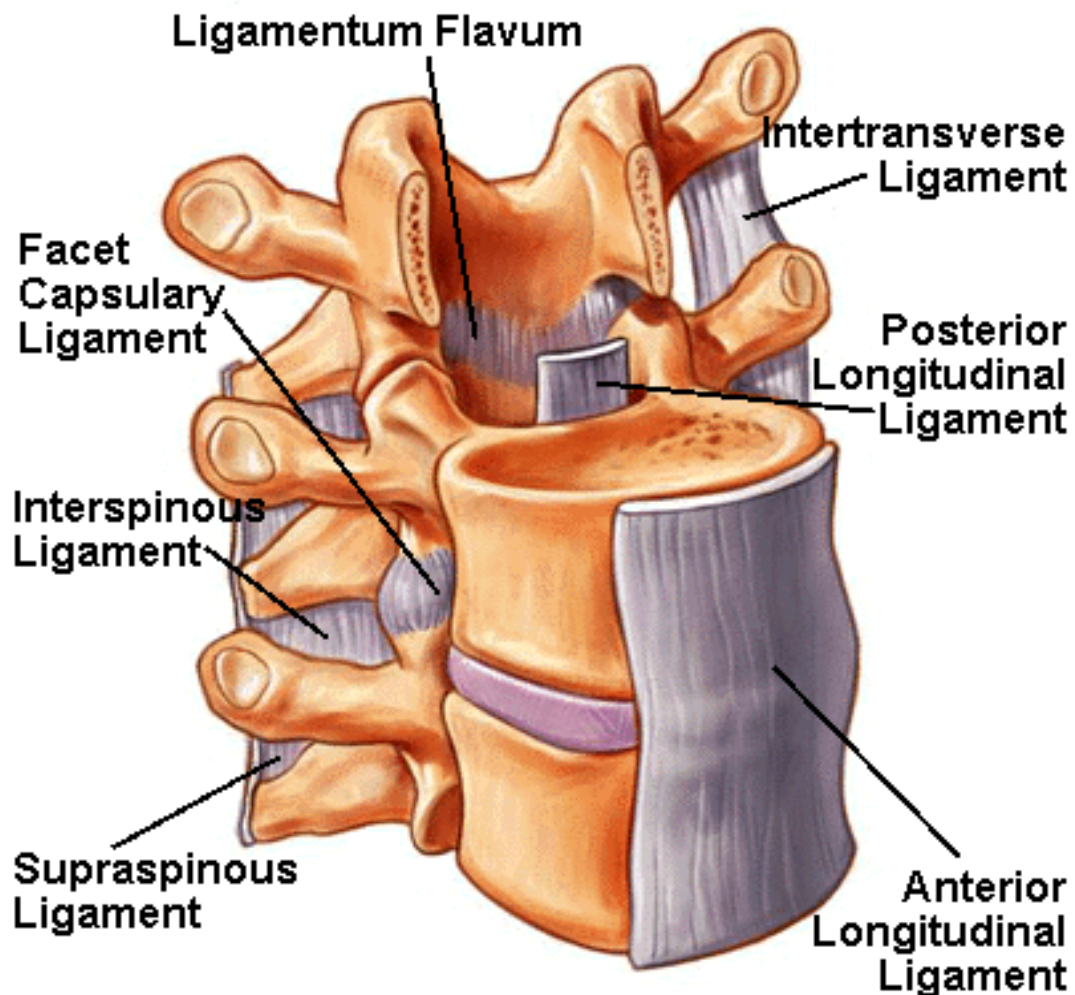


Figure 10. Ligaments of the Spin

Degenerative changes in the ligaments, such as hypertrophy or ossification, are often associated with the development of spinal stenosis, narrowing of the spinal canal, and subsequent compression of nerve roots. Clinically, these changes manifest as pain, restricted mobility, neurological deficits, and weakness of the lower extremities.

In the rehabilitation of lumbar pain syndrome, it is essential to target strengthening of the deep stabilizing muscles, along with stretching and mobilization of superficial muscles, while maintaining the flexibility and elasticity of ligamentous structures. Proper activation of supporting muscles reduces the risk of injury and chronic pain, while improving functionality and overall quality of life for patients.

2

Etiology and Classification of Low Back Pain

2.1 Mechanical and Non-Mechanical Causes

Low back pain (lumbar pain) results from a range of different causes and, in everyday clinical practice, is commonly classified into mechanical and non-mechanical categories to facilitate diagnostic assessment and optimise treatment. Understanding the aetiology is crucial for the timely identification of at-risk patients and for guiding both diagnostic and therapeutic strategies.

Mechanical causes account for around 90% of all cases of low back pain and include structural and functional disorders of the vertebral bony-articular, muscular, and ligamentous

systems. The most important mechanical causes include:

Mechanical causes account for around 90% of all cases of low back pain:

- *Degenerative changes of the intervertebral discs (discopathies)*
- *Intervertebral disc herniation*

- Degenerative changes of the intervertebral discs (discopathies) – gradual degeneration leads to loss of disc height and elasticity, reduced shock absorption, and an increased risk of nerve root irritation. Degenerative changes may result in chronic pain, but can also produce acute episodes if disc herniation or protrusion occurs.

- Intervertebral disc herniation – when part of the disc extends beyond its physiological position and compresses a nerve root, it causes typical radicular symptoms such as leg pain (sciatica).



Figure 11. Degeneration and herniation of the intervertebral disc

- Spinal stenosis – narrowing of the spinal canal or intervertebral foramina, most commonly caused by degenerative processes, leading to neurogenic claudication, numbness, weakness, and restricted mobility.
- Spondylolysis and spondylolisthesis – spondylolysis refers to a defect in the pars interarticularis, while spondylolisthesis denotes forward slippage of a vertebra, which may cause instability, chronic pain, and neurological symptoms.

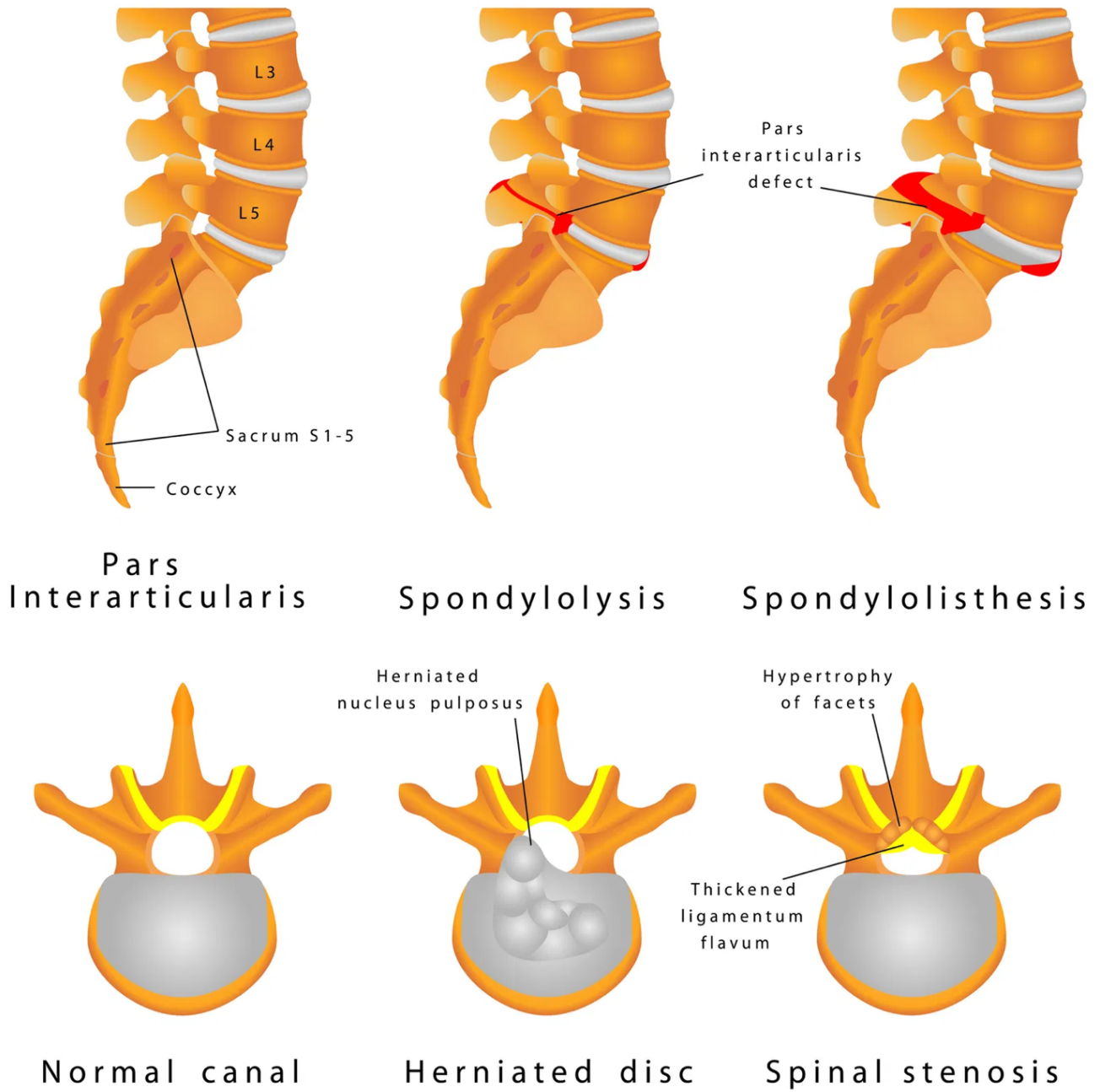


Figure 12. Illustration of spinal stenosis, spondylolysis, and spondylolisthesis

- Muscle and ligament injuries – acute or chronic overload leads to strains, tears, spasms, and the development of myofascial pain syndromes. These are the most common causes of acute non-specific pain.

Lumbar Spine Injuries

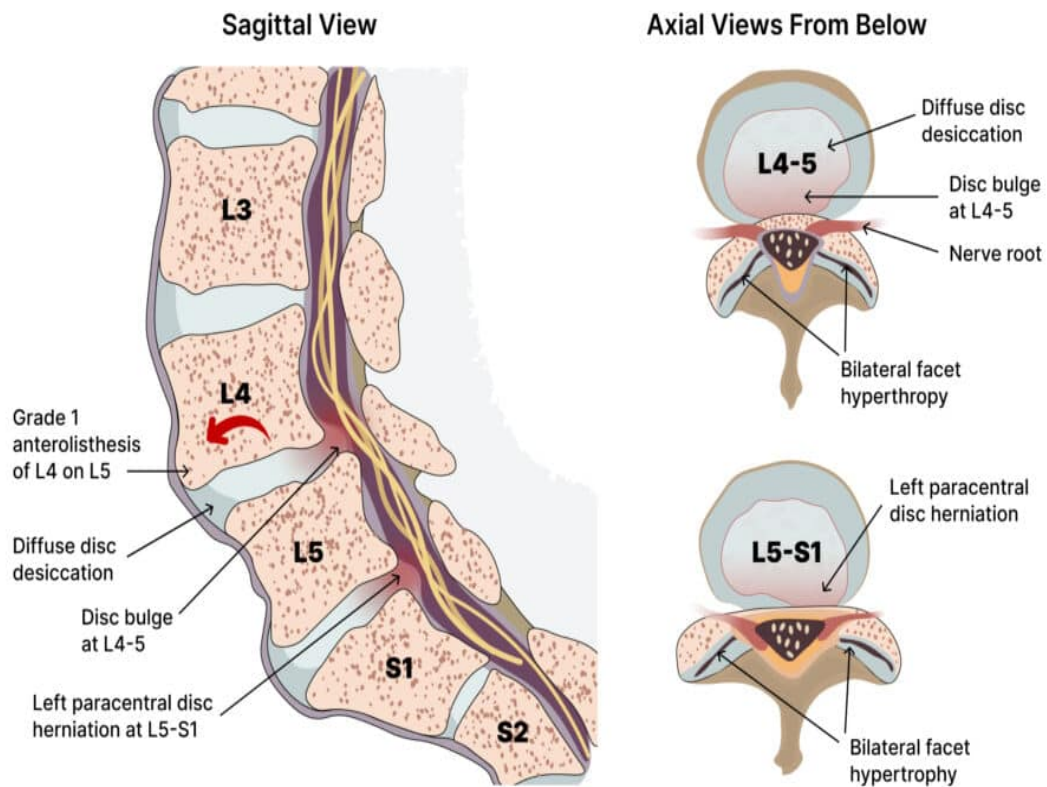


Figure 13. Injuries lumbar spine

- Postural deformities and functional imbalances (scoliosis, hyperlordosis, muscle weakness and shortening) create uneven loading on individual spinal segments and increase the risk of microtrauma, accelerated degeneration, and pain.

Non-mechanical causes are less common, but must always be considered, particularly in cases with atypical pain progression, the appearance of alarming symptoms (weight loss, fever, night pain, progressive neurological deficits), or poor response to standard therapy. The most important non-mechanical causes include:

- Inflammatory rheumatological diseases – most commonly ankylosing spondylitis and other seronegative spondyloarthropathies. The pain is usually chronic, present at rest, and accompanied by morning stiffness.

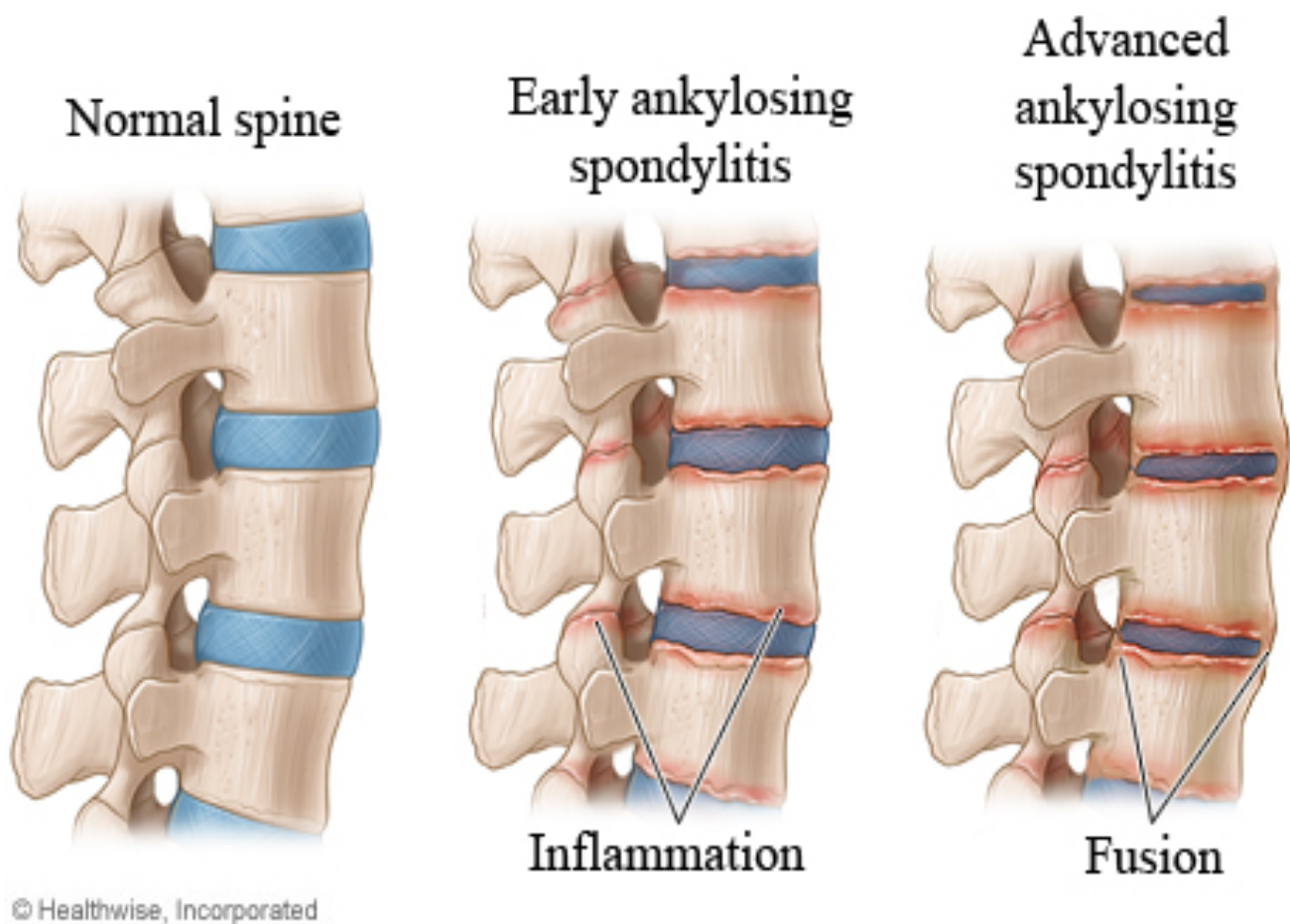


Figure 14. Ankylosing spondylitis

- Spinal infections – spondylodiscitis, osteomyelitis, and spinal tuberculosis may lead to destruction of bone and soft tissues, often accompanied by fever and systemic symptoms.

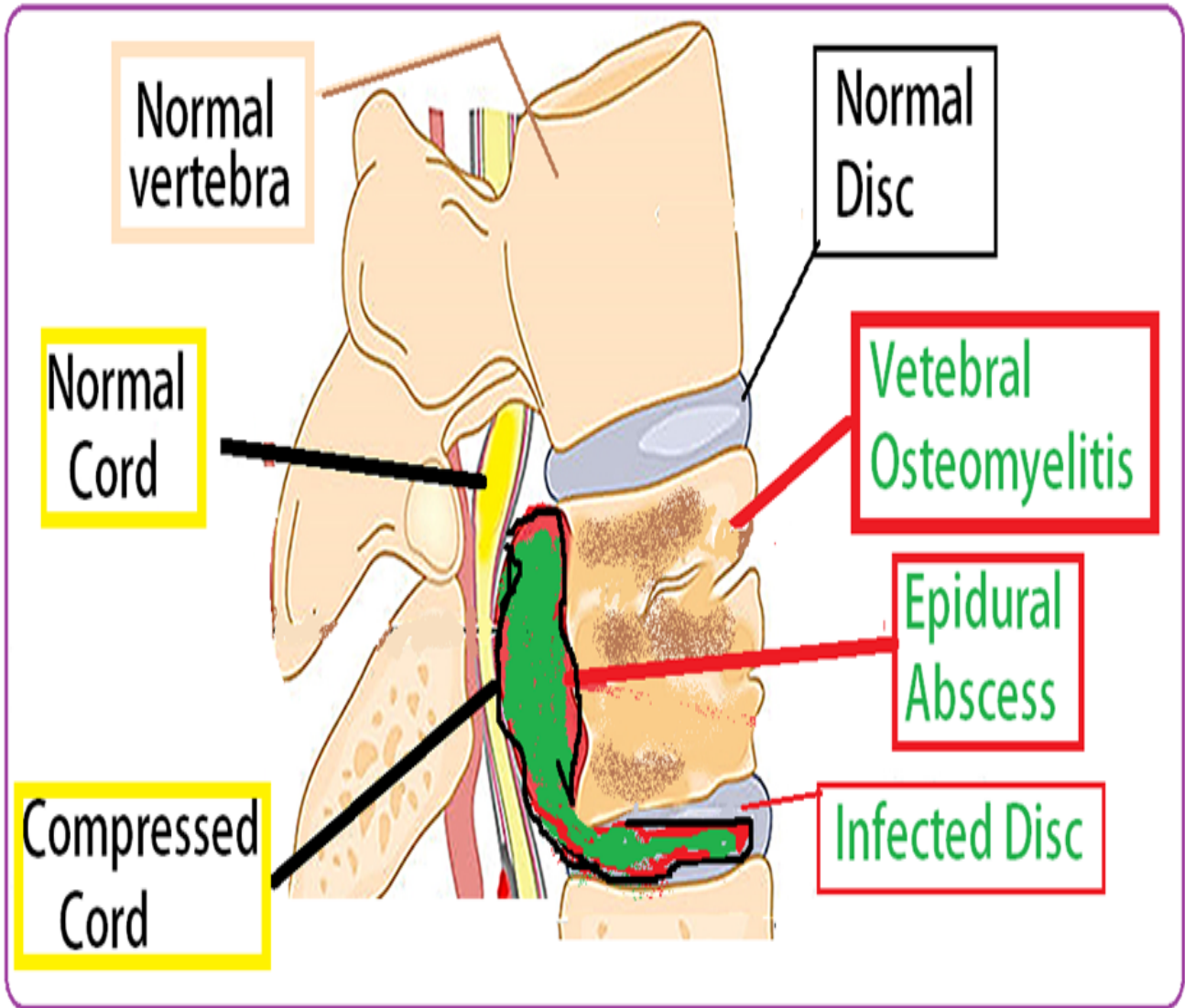


Figure 15. Depiction of disc infection



Figure 16. MRI scan of spondylodiscitis

- Neoplastic diseases – may be primary spinal tumours (plasmacytoma, haemangioma) or metastases (most commonly from the prostate, breast, lung, or kidney). The pain is often constant, worse at night, and unresponsive to usual analgesics.
- Visceral causes – diseases of abdominal and pelvic organs (kidney stones, urinary tract infections, pancreatitis, abdominal aortic aneurysm, gynaecological conditions) may produce referred pain in the lumbar region.

- Psychogenic factors – emotional stress, depression, anxiety, and social problems may heighten pain perception and prolong the course of illness (the so-called biopsychosocial model of pain).

Accurate and timely differential diagnosis is based on thorough history taking, clinical examination, and, where necessary, targeted laboratory and radiological investigations. It is essential to recognise red flags and refer the patient for urgent evaluation when indicated. Correctly distinguishing mechanical from non-mechanical causes enables optimal therapeutic decision-making, shortens recovery time, and reduces the risk of symptoms becoming chronic.

2.2 Acute, Subacute, and Chronic Pain

The duration of symptoms is a key criterion for classifying low back pain (LBP), profoundly impacting clinical reasoning, diagnostic pathways, therapeutic selection, and prognosis. Categorizing pain into acute, subacute, and chronic stages guides healthcare professionals in tracking disease progression and selecting the most appropriate interventions for each patient.

- Acute pain (up to 6 weeks): Acute low back pain usually presents suddenly, often triggered by a specific event such as lifting, twisting, or minor trauma. The most common causes are mechanical—muscle or ligament strain, acute disc irritation, or facet joint dysfunction. Clinically, acute pain is intense, sharply localized to the lower back, sometimes accompanied by limited mobility and reflex muscle spasm. Neurological deficits (e.g., weakness, numbness) are generally absent. The prognosis for acute pain is highly favorable: more than 80% of episodes resolve spontaneously or with conservative measures, including rest (not prolonged), non-opioid analgesics, and the gradual resumption of activities as tolerated. Application of cold/heat packs and patient education about maintaining activity are also beneficial. Imaging or laboratory testing is rarely required unless “red flag” features are present (recent trauma, unexplained fever, progressive neurological impairment, or suspicion of infection/malignancy).
- Subacute pain (6–12 weeks): Subacute LBP marks a transition when initial acute symptoms persist, recur, or partially improve but never fully resolve. This stage may arise from inadequate early management, premature return to normal activity, or pre-existing functional limitations. Clinical emphasis shifts to functional rehabilitation—introducing structured exercise programs (kinesiotherapy), physiotherapy, and patient education about

movement patterns and ergonomics. Early restoration of function and prevention of fear-avoidance behaviors (“kinesiophobia”) are crucial. Identification of psychosocial and occupational risk factors for chronicity is recommended, as subacute pain often signals higher risk for persistent or recurrent symptoms if not actively addressed.

- Chronic pain (over 12 weeks): Pain persisting beyond three months is considered chronic LBP, affecting 10–20% of individuals with back pain. The pathophysiology is multifaceted: peripheral sources of nociception may still be present, but central sensitization becomes prominent, altering pain perception and transmission in the nervous system. Psychological and social variables—such as depression, anxiety, pain catastrophizing, low job satisfaction, and limited social support—amplify and sustain pain. Chronic LBP is linked to reduced work ability, social withdrawal, and escalating healthcare costs. Management requires a biopsychosocial approach—blending tailored physiotherapy (exercise, manual therapy, patient education), psychological interventions (e.g., cognitive-behavioral therapy), and pharmacologic management (analgesics, antidepressants, adjuvant medications). Patient education regarding the chronic nature of pain, self-management techniques, relapse prevention, and re-engagement in daily life is central to therapy.

Classifying low back pain by duration serves as the foundation for modern therapeutic algorithms and guidelines, enabling clinicians to structure care, monitor outcomes, and provide targeted interventions that improve recovery and reduce the risk of chronic disability.

3

Clinical Presentation and Diagnosis

3.1 Symptoms and Functional Limitations

Lumbar Pain Syndrome (LPS) is most commonly characterized by dull, aching, burning, or sometimes stabbing pain localized in the lower back region, but the clinical presentation can vary greatly depending on the etiology, chronicity, and associated complications. In early or mild cases, pain may be episodic and linked to specific movements or postures (such as bending or lifting). As the condition progresses, pain intensity increases, can become constant, and starts to interfere with normal daily activities.

Radiating pain is a hallmark of nerve root involvement: patients may describe symptoms traveling from the lower back into the buttocks, outer thigh, and down the leg. If there is nerve compression (radiculopathy), as with disc herniation (most often at L4–L5 or L5–S1), pain may follow a dermatomal path all the way to the foot and be accompanied by burning, tingling, or “electric shock” sensations. In cases of spinal stenosis, pain can affect both legs and is often associated with muscle weakness, heaviness, or fatigue during walking (neurogenic claudication), which may improve with rest or spinal flexion.

Typical aggravating factors include:

- Prolonged sitting or standing, especially in static or poor postural positions,
- Physical exertion, bending, trunk rotation, or lifting objects,
- Nighttime or early morning pain and stiffness—more prominent in inflammatory or rheumatologic disorders.

Other common features of LPS:

- Stiffness and a feeling of “locking up” in the lower back, particularly after inactivity or upon waking,
- Reduced flexibility and range of motion, especially forward bending or side-to-side movement,
- Muscle weakness, hypotrophy, or atrophy in the paraspinal and lower limb muscles, particularly with prolonged inactivity or chronic pain,
- Neurological symptoms: numbness, tingling (paresthesia), diminished sensation (hypesthesia), reduced deep tendon reflexes, and—less frequently—motor deficits or gait disturbance,
- Presence of “red flags”: progressive motor weakness, loss of bladder or bowel control, sudden severe pain, unexplained weight loss, or fever should prompt investigation for more serious conditions (tumor, infection, fracture).

The psychological and social impact is considerable: in patients with chronic pain, there is a high prevalence of kinesiophobia (fear of movement), loss of confidence, depressive symptoms, anxiety, and feelings of helplessness. These factors further diminish functional capacity, prolong the rehabilitation process, and increase the risk of the pain becoming chronic and disabling.

Functional limitations are typically evident in everyday activities such as rising from bed, personal hygiene, dressing, driving, household chores, and participation in occupational or recreational activities. Due to reduced work capacity and restricted social and physical activities, many patients experience social isolation and a significant decline in overall quality of life.

All these symptoms and limitations must be carefully assessed through comprehensive medical history, clinical examination, and validated functional outcome measures (e.g., Oswestry Disability Index, Roland-Morris Disability Questionnaire), allowing for objective tracking of patient progress and treatment efficacy.

3.2 Differential Diagnosis

Low back pain (LBP) is among the most common presenting complaints in medical practice and can result from an extraordinarily broad array of underlying conditions. Because LBP is a non-specific symptom and many etiologies share similar clinical features, a thorough and systematic differential diagnosis is crucial—not only for effective therapy, but also for timely identification of serious or life-threatening diseases. Distinguishing between benign and “red flag” causes is essential, as some situations require urgent intervention.

Key elements of differential diagnosis include:

- **Degenerative spinal disorders:** Intervertebral disc herniation may compress neural structures and provoke radicular symptoms. Spondylosis and discogenic pain can cause narrowing of disc spaces, osteophyte formation, and mechanical pain. Facet joint osteoarthritis often presents as localized, morning pain and stiffness, which improves with movement.
- **Inflammatory rheumatologic diseases:** Conditions such as ankylosing spondylitis or other seronegative spondyloarthropathies present with chronic back pain, often nocturnal, improving with activity, and frequently involving the sacroiliac joints. Systemic features such as fever or malaise may also be present.
- **Neurological disorders:** Spinal stenosis can result in neurological deficits—weakness, sensory loss, diminished reflexes—while cauda equina syndrome is a medical emergency, marked by loss of bladder/bowel control, lower limb weakness, and perineal sensory loss. Nerve root compression (radiculopathy) is often characterized by dermatomal pain and muscle weakness.
- **Traumatic injuries:** Vertebral compression or traumatic fractures, ligament and muscle strains, contusions, and post-traumatic deformities must be considered in patients with sudden pain onset and relevant trauma history, especially in older adults or those with osteoporosis.
- **Visceral causes:** Referred pain from abdominal and pelvic organs can mimic primary low back pain—examples include renal colic, pyelonephritis, gynecological pain (endometriosis, cysts), gastrointestinal issues (pancreatitis, peptic ulcer), or vascular conditions (abdominal aortic aneurysm).
- **Infectious and neoplastic conditions:** Spondylodiscitis, spinal epidural abscess, tuberculosis, as well as metastatic or primary spinal tumors, warrant high clinical suspicion, particularly in the presence of systemic symptoms, night pain, or non-resolving pain.

- Psychosomatic factors: Chronic stress, depression, anxiety, and somatization disorders significantly amplify pain perception and prolong recovery. The biopsychosocial model is particularly relevant for chronic or recurrent pain.

A comprehensive diagnostic approach includes:

- Detailed history-taking: Assess onset, duration, and quality of pain; precipitating and relieving factors; presence of neurological symptoms; history of trauma or systemic illness; associated features like fever, weight loss, or sphincter disturbance.
- Thorough physical examination: Evaluate posture and gait, palpation for tenderness, range-of-motion tests, full neurological assessment (sensation, motor strength, reflexes), Lasègue's sign, muscle testing, and provocative maneuvers.
- Standardized questionnaires: Use of validated tools (e.g., Oswestry Disability Index, Roland-Morris Disability Questionnaire) for objective quantification of functional impairment.
- Imaging studies: Tailored to the clinical context; plain radiographs (X-ray) may reveal fractures or gross deformities, MRI is the gold standard for soft tissue and disc evaluation, and CT is valuable for bone pathology. Laboratory tests (CRP, white blood cell count, tumour markers, serology) may be indicated if infection, malignancy, or systemic disease is suspected.
- Additional methods: Electromyoneurography (EMG/NCV) for suspected neuropathy or muscle disorders, abdominal ultrasound for suspected visceral pathology, and referral to appropriate specialists as necessary.

A structured, multidisciplinary diagnostic process enables not only precise identification of the pain generator, but also optimization of therapy and prevention of chronicity or severe complications.

4

Radiological Diagnostics

4.1 Role of Imaging

Radiological diagnostics represent a key component in the assessment of patients with lumbar pain syndrome (LBS), but their use should be guided by clearly defined clinical indications. In everyday practice, the greatest value of imaging methods lies in identifying potentially serious or atypical causes of pain, whereas in most patients with acute non-specific low back pain, routine radiological assessment is not required.

In order to formulate a clear clinical question, it is necessary to select the appropriate radiological method that provides a precise insight into the problem at hand. It is also essential to understand the available radiological techniques and all their characteristics and capabilities. Cooperation between all healthcare professionals is crucial. The examinations that help in diagnosing low back pain include computed tomography (CT), ultrasonography (US), conventional radiography, magnetic resonance imaging (MRI) and electromyography (EMG). Less frequently, laboratory tests may be required.

Indications for imaging include:

- Persistent or progressive symptoms that do not respond to standard therapy for 6 weeks or longer.
- The presence of red flags: sudden weight loss, fever, history of malignant disease, night pain, neurological deficits, sphincter disturbances, suspicion of infection or fracture.
- Preparation for invasive procedures or surgical treatment, where precise localisation and assessment of the extent of pathology are essential for planning therapy.

- Situations where there is suspicion of secondary causes of low back pain, including tumorous lesions, spinal infections, inflammatory changes or vascular malformations.

Radiological methods used:

- Radiography (X-ray): A basic method that enables assessment of the bony structures of the spine, detection of fractures, spondylolisthesis, deformities and gross degenerative changes. However, X-ray does not visualise soft tissues or neural structures and is used mainly as an initial examination when fracture is suspected or in older patients.



Figure 17. X-ray device

- Magnetic resonance imaging (MRI): The gold standard for evaluating intervertebral discs, the spinal cord, nerve roots and soft tissues. MRI is the method of choice when disc herniation, radiculopathy, tumours, infections or unclear neurological deficits are suspected.



Figure 18. MRI device

- Computed tomography (CT): Suitable for detailed analysis of bony abnormalities, imaging of fractures and planning certain interventions. CT provides cross-sectional images using ionising radiation. It is particularly useful for displaying bony structures, loose bodies within joints and the topographical relationship between bony and soft-tissue structures. CT detects abnormalities that may also be present in asymptomatic individuals, but does not allow evaluation of the internal structure of the intervertebral disc. When MRI cannot be performed, or when MRI findings do not provide a clear depiction of canal or foraminal narrowing, CT is the preferred alternative. The major disadvantages of CT are its high radiation dose and limited specificity.



Figure 19. CT device

- Scintigraphy, PET-CT, ultrasonography: Additional methods used in specific clinical situations—suspected inflammation, metastases, vascular causes or treatment monitoring. When an acute bony disorder is suspected, bone scintigraphy may assist in the evaluation of low back pain. However, scintigraphy is not routinely used in patients with low back pain, and its main drawbacks are very low specificity and high radiation exposure. Ultrasonography (US) is used to visualise superficial soft-tissue structures. High-resolution ultrasound can demonstrate structural changes in the intervertebral disc, but careful attention must be paid to identifying the correct segment level, as US is not the most reliable method for this purpose.



Figure 20. Ultrasound device

Limitations of imaging

It is important to emphasise that radiological findings often do not correlate with the severity or nature of symptoms. Many asymptomatic individuals have radiologically confirmed degenerative changes, whereas some patients with severe pain may have normal imaging results. Therefore, clinical evaluation must always take precedence, and interpretation of findings should be individualised and carefully aligned with the patient's symptoms and functional status. Unnecessary or overly frequent imaging may lead to false-positive findings, increased patient anxiety, additional costs and avoidable invasive interventions.

Conclusion

Imaging is indispensable when serious pathology is suspected or when planning invasive procedures, but it should never replace thorough history taking, clinical examination and functional assessment. Educating patients about the nature of radiological findings is an important tool for reducing anxiety and promoting a rational approach to treatment.

4.2 X-ray, MRI, CT and Diagnostic Guidelines

The most commonly used imaging methods in the evaluation of lumbar pain syndrome (LBS) are radiography (X-ray), magnetic resonance imaging (MRI) and computed tomography (CT). The choice of method depends on the clinical presentation, duration of symptoms, presence of neurological deficits and the suspected underlying pathology.

Conventional radiography (X-ray)

When discussing radiological methods, it should be emphasised that conventional radiography is the most frequently used technique and the only one that visualises bony structures; it has been in use since 1895. It is the most accessible and widespread method. Radiography can demonstrate a reduction in intervertebral space and distinguish acquired from congenital deformities of the spine. Other abnormalities detectable with this method include reactive bony changes, osteolysis, osteoplastic changes, oncological disease, discontinuity of bony structures and vertebral protrusion.

This method is used to rule out serious conditions, but its major limitation is poor visualisation of the myofascial system.

Radiography is a traditional and readily available technique that enables basic visualisation of bony structures. It is most commonly used as the first-line diagnostic tool when fractures, spondylolisthesis, structural deformities (such as scoliosis or kyphosis), or advanced degenerative changes (osteophytes, reduced disc height, calcifications) are suspected. The advantages of X-ray imaging are rapid availability and low cost, but its main limitation is the inability to visualise soft tissues, intervertebral discs, nerve roots and the spinal cord. Therefore, X-ray is now primarily used as an orientation method or when trauma is suspected, particularly in older patients at risk of osteoporotic fractures.

Magnetic resonance imaging (MRI)

MRI is the gold standard for assessing soft-tissue structures of the spine, intervertebral discs, the spinal cord and nerve roots. It is a highly sophisticated, non-ionising imaging method providing the most detailed depiction of anatomical structures and pathological changes. It is invaluable in identifying anatomical detail and pathological substrates.

The advantages of MRI over other methods include multiplanar imaging, the absence of ionising radiation, excellent visualisation of the myofascial system, and high spatial and contrast resolution. It also enables functional assessment of the central nervous system. When a detailed understanding of low back pain is required—particularly when radiculopathy is suspected—MRI is the preferred method.

Because MRI does not use ionising radiation, it is especially important for younger patients, pregnant women and individuals who require repeated imaging. Indications for MRI include pain lasting longer than six weeks, persistent or progressive neurological deficits, suspicion of tumour or infection, and unclear or atypical clinical presentations.

Computed tomography (CT)

CT provides exceptionally detailed visualisation of bony structures, making it particularly valuable in detecting complex fractures, spondylolysis, foraminal narrowing and calcified herniations. It is also useful when MRI is unavailable or contraindicated (e.g., in patients with metal implants, pacemakers, or severe claustrophobia). CT allows assessment of the relationship between soft-tissue and bony components, but it uses ionising radiation and should therefore be used judiciously, particularly in younger individuals.

Diagnostic guidelines

Modern international and national guidelines (NICE, ACR, EULAR, Croatian rheumatology societies) highlight the importance of restrictive and rational use of radiological diagnostics.

- In acute, uncomplicated cases of low back pain, imaging should be deferred for at least six weeks, as most symptoms resolve spontaneously with conservative management (analgesics, physical therapy, patient education).
- Imaging is justified in the presence of red flags, such as:
 - Recent trauma or fall
 - Progressive loss of strength or sensation in the legs
 - Loss of bladder or bowel control (suspected cauda equina syndrome)
 - Significant unexplained weight loss
 - History of malignancy, chronic inflammatory disease, infection or immunosuppression
 - Night pain disturbing sleep

Final remark

Unnecessary or overly frequent use of radiological methods without clear clinical indication may lead to false-positive findings, unnecessary interventions and additional strain on the healthcare system. Therefore, decisions regarding imaging must be made individually, based on careful clinical evaluation and adherence to current guidelines.

5

Physical Therapy in Lumbar Pain Syndrome

5.1 Magnetotherapy, electrotherapy, ultrasound and laser

Physical therapy occupies a central place in the non-operative management of lumbar pain syndrome (LPS), acting not only symptomatically but also on deeper pathophysiological processes. In addition to reducing pain intensity, it accelerates tissue regeneration and restores functionality, potentially significantly reducing the need for pharmacological therapy. This, in turn, minimises medication-related side effects and improves patients' quality of life.

Physical therapy is recommended for patients with a chronic course of disease. Analgesic therapy is continued according to the physician's instructions, and it is essential to educate the patient and their family about the rehabilitation process. If these measures are insufficient or if no improvement occurs within 4 weeks to 2 years, the patient is referred for surgical intervention.

In lumbar pain syndrome, the primary goal is to reduce pain and increase functional capacity to enable better performance of daily activities, both at work and in private life. Pain symptoms arise within an individual vertebral dynamic segment and may have vertebral or vertebrogenic origins. The therapeutic approach is similar across many causes that lead to clinical symptoms.

Various approaches are used in treatment:

- pharmacological
- educational
- anatomical

- functional
- behavioural
- psychological

Many patients require a pharmacological approach, while those with indications for surgery require an anatomical approach. Patients with chronic diagnoses who need psychological support are advised to follow a behavioural approach. Each patient requires an individualised treatment plan tailored to their diagnosis and needs. Consequently, symptoms are treated more often than the underlying cause, with pharmacological therapy frequently applied.

In the acute phase of rehabilitation, rest is recommended. Treatment includes various therapeutic options: analgesic therapy, application of nerve blocks, pain clinics or acupuncture, and orthopaedic aids.

The use of different physical therapy modalities is based on scientific evidence, individual patient characteristics and the stage of disease.

Magnetotherapy (PEMF – Pulsed Electromagnetic Field)

Magnetotherapy uses low-frequency electromagnetic waves to penetrate deeply into tissues. Clinical research shows that this method enhances microcirculation, stimulates cellular repair processes and modulates inflammatory reactions. It is particularly recommended for chronic degenerative diseases such as spondylosis and osteoarthritis, and for patients who cannot tolerate intensive manual therapy. A treatment cycle typically consists of 10–20 sessions, applied 3–5 times per week, and the procedure is painless and safe. In clinical practice, many patients report reduced stiffness, improved mobility and decreased need for analgesics.

Electrotherapy

The therapeutic use of electrical current in rehabilitation is referred to as electrotherapy. Low-, medium- and high-frequency currents are distinguished. The primary effects of electrotherapy include pain reduction through inhibition of nociceptors, modulation of pain transmission and increased endorphin levels. Additional secondary and synergistic effects include reduction of oedema or ischaemia, modulation of muscle spindle sensitivity, reduced muscle spasm, enhanced blood circulation and increased resorption of harmful metabolites.

For pain reduction, the most commonly used modality is transcutaneous electrical nerve stimulation (TENS). Galvanic current is a direct current of constant intensity derived from alternating current.

The main physiological effects of galvanic current include:

- improved circulation
- pain reduction
- vasodilation
- increased nerve conductivity and excitability

Low-frequency currents include TENS, functional electrical stimulation (FES), electroneurostimulation and muscle electrostimulation. Electrical stimulation activates sensory and motor nerves as well as skeletal and smooth muscle using electrical impulses. These modalities are most often used in nerve paresis caused by disc prolapse. TENS is widely used because it is simple to apply, practical and safe.

This group also includes interferential currents, diadynamic currents and other stimulation types. TENS is most frequently used for acute and chronic pain and acts through the spinal “gate-control” mechanism, rapidly decreasing pain perception. Interferential currents (IFC) are applied for deeper, chronic pain by combining two currents to create a therapeutic effect in deeper tissues. Electrotherapy may also improve muscle tone, reduce spasms, increase local circulation and accelerate the elimination of metabolic by-products. Treatment protocols are tailored to the individual, typically lasting 10–30 minutes per session.

Ultrasound Therapy (US)

Ultrasound therapy uses high-frequency sound waves that create mechanical vibrations within tissues. It has thermal and non-thermal effects: it increases local temperature, enhances enzymatic activity, accelerates the breakdown of inflammatory by-products and improves the flexibility and elasticity of connective tissue. Ultrasound is particularly effective for myofascial syndrome, contusions, sprains and subacute soft-tissue injuries. Treatment is delivered using a contact probe and gel, lasting 5–15 minutes per region, and may be combined with other modalities for faster recovery.

Low-Level Laser Therapy (LLLT)

Light Amplification by Stimulated Emission of Radiation—laser—represents the amplification of light through stimulated radiation emission. Physicist Albert Einstein described the theory of stimulated emission in 1917, and the principle of laser operation has been known since then. Lasers used in physical medicine fall into the category of low-power lasers, which do not damage healthy tissue and have no thermal effects. Their action may be described as biostimulatory and bioinhibitory; thus, the term biomodulation is more appropriate.

Key characteristics of laser light include:

- a single wavelength
- coherence in time and space
- collimation of the light beam

Laser therapy is used to promote healing of wounds and ulcers by stimulating fibroblasts. It increases wound flexibility, enhances leukocyte phagocytosis, produces a bactericidal effect, and reduces swelling and prostaglandin E₂ synthesis. Laser therapy is applied in disc herniation due to its analgesic effect and its role in stimulating bone and cartilage remodelling.

Laser may be applied using several techniques:

- scanning technique – laser is applied over painful areas
- grid technique
- point-by-point application at painful trigger points

Low-level laser therapy uses low-intensity light energy to biostimulate cells. Its mechanism involves increased ATP synthesis, fibroblast activation, accelerated tissue regeneration and strong anti-inflammatory effects. LLLT is virtually painless and suitable for long-term use. It is employed in treating chronic pain, neuralgia, tendinopathy and as support in early recovery after acute injuries. In addition to reducing pain, it has been shown to improve functional outcomes and shorten rehabilitation time.

Combined Protocols and Integration of Therapies

In contemporary rehabilitation practice, a combination of several physical therapy modalities is often used to achieve maximal therapeutic effect. The choice of methods depends on disease stage, clinical findings, comorbidities and equipment availability. It is important to highlight that physical

therapy is most effective when complemented by active methods such as kinesiotherapy exercises, patient education and postural correction. In chronic cases, a targeted combination of physical treatments can slow disease progression, reduce disability risk and improve long-term patient functionality.

5. 2 Mechanisms of Action and Indications

Each of the modern physical therapy methods used in the treatment of lumbar pain syndrome (LPS) is based on specific biological and physiological processes which, when applied correctly, enable effective symptom reduction and promote recovery. Understanding the mechanisms of action is crucial for an individualised therapeutic approach, adaptation of protocols and optimisation of outcomes.

Magnetotherapy

Magnetotherapy uses a pulsed low-frequency electromagnetic field to induce changes at the level of the cell membrane and intracellular structures. The pulsed field stimulates ion exchange (particularly calcium, sodium and potassium), thereby influencing the excitability of nerve and muscle cells and modulating the local inflammatory response. Blood flow in the treated area is increased, which improves the delivery of oxygen and nutrients and accelerates the elimination of metabolic waste products. The result is a reduction of oedema, inhibition of inflammatory cytokine synthesis and stimulation of reparative processes. Additionally, reduced muscle tension and improved microcirculation contribute to a faster return of functional capacity.



Figure 21. Magnetotherapy device

Electrotherapy (TENS and other methods)

The principle of electrotherapy is grounded in the “gate control” theory of pain. Activation of large, myelinated $A\beta$ nerve fibres inhibits the transmission of pain impulses from peripheral nociceptors ($A\delta$ and C fibres) to the central nervous system. This results in immediate pain relief without pharmacological action. Beyond analgesia, electrotherapy can induce muscle contraction, enhance lymphatic drainage, accelerate oedema resorption and support nerve regeneration. Interferential and diadynamic currents are used in chronic pain and severe muscular imbalances, while individual adjustment of frequency, intensity and treatment duration allows precise tailoring to each patient.



Figure 22. Electrotherapy device

Ultrasound Therapy

Ultrasound exerts both mechanical and thermal effects. High-frequency vibrations create micromassage that breaks down microscopic adhesions in soft tissues, improves blood and lymphatic flow and stimulates fibroblasts and collagen synthesis. The thermal effect increases the temperature of deeper tissue layers, enhancing enzymatic processes, accelerating the elimination of inflammatory mediators and improving the elasticity of tendons and ligaments. This modality is particularly valuable for microtraumas, tendon injuries, tension-related muscular syndromes and myofascial pain, as it enables a faster return to normal biomechanics.



Figure 23. Therapeutic ultrasound device

Low-Level Laser Therapy (LLLT)

Photobiomodulation with laser is based on the absorption of low-intensity light energy within cellular mitochondria, which stimulates adenosine triphosphate (ATP) synthesis, promotes fibroblast division and migration and increases local growth factor production. Levels of pro-inflammatory prostaglandins (PGE₂) decrease, and the synthesis of bradykinin and histamine is inhibited, leading to reduced inflammation, oedema and pain. Furthermore, laser therapy can accelerate wound healing, enhance haematoma resorption and stimulate immune responses at the cellular level.

Expanded clinical indications:

- Non-specific and chronic low back pain (lumbar syndromes of various aetiologies)

- Muscle-tension and myofascial pain syndromes, including trigger points
- Discopathies, protrusions and extrusions with or without radiculopathy
- Postoperative rehabilitation (after lumbar discectomy, decompression, spondylodesis)
- Degenerative spinal disorders: spondylosis, facet joint syndrome, osteoarthritis, spinal stenosis
- Acute and subacute soft-tissue injuries (sprains, contusions, partial tears)
- Overuse syndromes and postural disorders
- Rehabilitation after trauma or immobilisation (loss of function, muscle weakness, reduced range of motion)
- Prevention of recurrent injuries and pain episodes in professionals and athletes

All methods are used according to clearly defined indications, and correct selection, monitoring and evaluation of therapeutic effects are essential for successful rehabilitation and long-term prevention of symptom recurrence.



Figure 24. Therapeutic laser device

6

The Role of Kinesiotherapy

6.1 Types of Exercises and Protocols

Physical therapy holds the most significant role in the rehabilitation of patients with lumbar pain syndrome (LPS). The most common therapeutic modality in the rehabilitation process is kinesiotherapy. Kinesiotherapy is a scientific discipline within medicine that uses movement as a means of treatment. In cases of acute disc prolapse, kinesiotherapy is not recommended; however, according to current research, exercise is considered the better option during the chronic phase of the condition. The main goal of therapy is to increase the mobility of the vertebral dynamic segment (VDS) and to improve the range of motion of the lumbar spine. It is essential to familiarise the patient with exercises that enhance stabilisation and activate the paravertebral musculature. Stability is achieved through adequate coordination of muscle control and the physiological positioning of joints. Achieved stabilisation involves exercises for strengthening the core musculature and posture training. To prevent recurrence of pain and ensure a return to activities of daily living, kinesiotherapy is necessary, with each treatment cycle individually tailored to the patient. Depending on how they are performed, exercises are classified as active or passive (usually applied for approximately one month). Rehabilitation is complex because it includes numerous therapeutic processes aimed at improving neural conduction, innervation of specific muscle groups, reducing inflammation and alleviating pain.

Kinesiotherapy represents the foundation of rehabilitation in lumbar pain syndrome (LPS), emphasising the importance of active patient participation and a systematic, scientifically guided approach to restoring function. The primary goals are to restore full functionality, reduce pain, increase strength and mobility, and prevent symptom recurrence and chronicity.

1. Stretching exercises

Stretching is the first and fundamental component of every kinesiotherapy programme. Regular, targeted stretching helps reduce muscle tension, particularly in muscles often shortened in LPS (iliopsoas, hamstrings, gluteal muscles and paravertebral musculature). In addition to improving elasticity, stretching reduces myofascial restrictions and enhances blood circulation. Static stretching is recommended, with each position held for at least 20–30 seconds, gradually increasing duration and intensity according to tolerance. Incorporating dynamic techniques may be useful in later rehabilitation phases when preparing the body for everyday functional demands.

2. Isometric and isotonic exercises

Isometric exercises, which involve muscle activation without joint movement, are excellent for the early stages of rehabilitation because they reduce pain, activate core stabilisers (e.g., transversus abdominis, multifidus) and do not load painful or sensitive structures. As pain decreases and function improves, isotonic exercises with progressive resistance (e.g., trunk extensions, pelvic lifts, squats) are introduced to strengthen the spinal musculature, stabilise joints and improve endurance. Resistance bands and small weights are often used for additional progression.

3. Stabilisation training

Trunk stabilisation is considered the “gold standard” for preventing recurrence and ensuring optimal movement control. Performing exercises on unstable surfaces (balls, BOSU, balance boards) promotes activation of deep stabilisers, improving proprioception, balance and motor control. These exercises reduce the risk of microtrauma and injury, facilitate a safer return to daily and sporting activities, and are essential for athletes and individuals with recurrent symptoms.

4. Postural corrective exercises

Correcting faulty postural patterns is crucial for long-term rehabilitation success. These exercises include posture correction techniques, strengthening of the trunk, back and lower pelvic muscles, and mobilisation of stiff joints. Education on proper ergonomics, lifting techniques, sitting posture and computer work forms an integral part of every rehabilitation programme. Patients are encouraged to incorporate learned exercises into their daily routine to ensure long-term prevention.

5. Additional modalities and progression

For more advanced patients, dynamic stabilisation exercises, strength training with resistance, proprioceptive exercises (with eyes closed or on unstable surfaces), and coordination and agility drills are introduced. Each programme progresses gradually, with continuous monitoring of symptoms and alignment with the patient's individual goals.

6. Individualisation and safety of the programme

The exercise programme must be individualised according to pain level, current functionality, motivation, age, presence of neurological deficits, comorbidities and general physical condition. The initial assessment includes mobility tests (e.g., Schober test, flexion/extension), functional questionnaires (Oswestry, RMDQ) and muscle strength evaluation. Progress is regularly monitored during rehabilitation, with intensity adjustments, and the programme is modified if new symptoms or limitations appear. Patient safety is always the priority—in the acute phase, exercise is contraindicated.

7. Psychological aspects

Encouragement, motivation and psychological support are crucial for long-term adherence to the programme, especially in chronic patients. Group exercise sessions, guided education and clearly defined goals further enhance the effectiveness of kinesiotherapy.

6.2 Presentation of kinesiotherapy in the research

Exercise 1. Lumbar Spine Extension



Figure 25. Lumbar spine extension

1. The patient lies on their stomach, supporting the body with their forearms.
2. The patient presses the elbows into the floor to lift the upper back. While doing so, they relax the abdominal muscles and allow the back to extend without using the back muscles. As the patient presses the back upwards, they must ensure that the hips and pelvis remain in contact with the floor.
3. Hold this position for 15 to 30 seconds, then relax.
4. Repeat the exercise 2 to 4 times.

Exercise 2. Alternating Arm and Leg Exercise





Figure 26. Alternating arm and leg exercise

1. Note: The patient performs this exercise slowly, trying to keep the body straight at all times and preventing one hip from dropping lower than the other.
2. Position yourself on the floor on hands and knees.
3. Tighten the abdominal muscles.
4. Lift one leg off the floor and extend it straight behind. Ensure the hip does not drop, as this will cause trunk rotation.
5. Hold for approximately 6 seconds, then lower the leg and switch to the other side.
6. Repeat 8 to 12 times on each leg.
7. Over time, work towards holding each repetition for 10 to 30 seconds.

8. If the patient feels stable and secure with the leg raised, they may simultaneously raise the opposite arm straight in front.

Exercise 3. Knee-to-Chest Stretch



Figure 27. Knee-to-chest stretch

1. The patient lies on their back with knees bent and feet on the floor.
2. Bring one knee towards the chest while keeping the other foot flat on the floor (or keep the opposite leg straight, which is even better for the lower back).
3. The patient keeps the lower back pressed into the floor and holds the stretch for at least 15 to 30 seconds.
4. Relax and lower the knee to the starting position.
5. Repeat the exercise with the other leg. Perform 2 to 4 repetitions on each side.
6. To increase the stretch, the patient may extend the opposite leg fully while bringing the knee to the chest.

Exercise 4. Curl-Up



Figure 28. Curl-up exercise

1. The patient lies on the floor on their back with knees bent at a 90-degree angle. Feet are flat on the floor about 30 cm from the buttocks.
2. Cross the arms over the chest.
3. Slowly tighten the abdominal muscles and lift the shoulder blades off the floor.
4. Keep the head aligned with the body and avoid pressing the chin into the chest.
5. Hold this position for 1 to 2 seconds, then slowly lower the back to the floor.
6. Repeat 8 to 12 times.

Exercise 5. Pelvic Tilt



Figure 29. Pelvic tilt

1. The patient lies on their back with knees bent.
2. “Tighten” the abdomen—this means contracting the muscles by drawing the navel towards the spine. The patient should feel the back pressing into the floor as the hips and pelvis tilt backwards.
3. Hold for about 6 seconds while breathing steadily.
4. Repeat 8 to 12 times.

Exercise 6. Bridge



Figure 30. Bridge exercise

1. The patient lies on their back with knees bent and ankles positioned so that only the heels touch the floor. The knees should be bent to roughly 90 degrees.
2. Press the heels into the floor, tighten the gluteal muscles and lift the hips off the floor until the shoulders, hips and knees form a straight line.
3. Hold for about 6 seconds while continuing to breathe normally, then slowly lower the hips and rest for up to 10 seconds.
4. Repeat 8 to 12 times.

Exercise 7. Hamstring Stretch



Figure 31. Hamstring stretch

1. The patient sits on the bed with both legs extended.
2. Extend the arms and reach forward, bending from the hips as far as possible while keeping the knees straight.
3. Hold the stretch for 15 to 30 seconds.
4. Return to the starting position.
5. Repeat three times.

Exercise 8. Hip Flexor Stretch



Figure 32. Hip flexor stretch

1. The patient kneels on the floor with one knee bent in front and the other leg behind. Position the front knee over the foot. The back knee remains in contact with the floor.
2. Gently push the hips forward until a stretch is felt in the upper thigh of the back leg.
3. Hold the stretch for at least 15 to 30 seconds. Repeat on the other side.
4. Perform 2 to 4 repetitions on each side.

Exercise 9. Wall Squat



Figure 33. Wall squat

1. The patient stands with their back 30 cm away from the wall.
2. Lean back until the back is flat against the wall.
3. Slowly slide down until the knees are slightly bent, pressing the lower back into the wall.
4. Hold for about 6 seconds, then slide back up the wall.
5. Repeat 8 to 12 times.

6.3 Therapeutic Benefits of Kinesiotherapy

Regular, progressive and professionally guided kinesiotherapy provides a wide range of scientifically proven benefits for the rehabilitation and long-term health of patients with lumbar pain syndrome (LPS). Its advantages extend far beyond simple pain reduction, positively influencing nearly all aspects of physical and psychological functioning.

Improvement of neuromuscular control and proprioception

Through specific exercises and repeated movements, “muscle memory” is developed and the integration of sensorimotor pathways between the brain, spinal cord and trunk muscles is enhanced. This results in more precise movement control, better coordination and a reduced risk of incorrect loading during daily activities. Balance, stabilisation and proprioceptive exercises train the deep layers of the trunk musculature and enable automatic body responses to changes in position or sudden loads, which is particularly important for preventing new injuries.

Promotion of regeneration and prevention of recurrence

Activation of local stabilisers (e.g. m. multifidus, transversus abdominis) improves local circulation, supplying more oxygen and nutrients to the injured area, accelerating the resorption of inflammatory mediators and promoting healing processes. This reduces the risk of developing chronic, weakened or degenerative zones within muscles and ligaments. Kinesiotherapy also helps prevent new episodes of pain by strengthening the muscles that protect the spine, thereby reducing recurrence risk.

Restoration of functional independence

The ability to perform everyday activities with little or no pain improves significantly through properly supervised exercises. Patients return more quickly to work, recreational pursuits and social activities, which greatly enhances quality of life. The need for analgesics and frequent healthcare visits is also significantly reduced, lowering both personal and societal healthcare burdens.

Psychological effects

Regular movement and improvements in functional ability have a positive impact on the patient's psychological wellbeing. Kinesiotherapy has been shown to reduce symptoms of anxiety and depression associated with chronic pain, increase self-confidence and enhance the patient's sense of

control over their own body. Group sessions or paired therapy further boost motivation, reduce feelings of isolation and contribute to better mental health.

Prevention of future pain episodes

Learning correct movement patterns, ergonomics and postural awareness through kinesiotherapy is essential for reducing the risk of symptom recurrence. Patients acquire self-management strategies such as warming up before physical activity, proper lifting techniques and taking frequent micro-breaks during sedentary work—habits that help maintain spinal health in the long term.

Additional benefits

Systematic kinesiotherapy can positively influence metabolic health (improved circulation, reduced inflammation), enhance overall physical capacities (endurance, strength, flexibility) and prevent the development of other musculoskeletal disorders. Moreover, education and collaboration with healthcare professionals enable an individualised approach, increasing both safety and the long-term success of rehabilitation.

7

Clinical Study – 210 Patients

7.1 Methodology and Study Design

This clinical study represents one of the most comprehensive attempts to evaluate the effectiveness of different physiotherapeutic protocols in patients with lumbar pain syndrome (LPS). The study was designed as a prospective, controlled and randomised investigation, carried out over the course of an entire year, thereby allowing insight into therapeutic effects across different seasons and potential fluctuating factors that influence the onset and progression of LPS.

Research Methods

Participants were allocated to groups through a randomisation procedure regardless of age, sex or physical status, and were thus assigned the therapy prescribed for their respective group. If a patient reported the use of analgesics, this was considered as an additional measure of treatment effectiveness. Each patient underwent a standard radiograph of the lumbar spine in two projections.

A total of 210 participants were included in the study and distributed into seven groups: six experimental groups and one control group. The control group consisted of patients attending the department of physical medicine and rehabilitation for diagnoses unrelated to lumbar pain syndrome. Each patient completed 10 treatment cycles over 10 days. The mean age of the participants was 50.11 years (SD = 12.9 years). There was no statistically significant age difference between groups ($p = 0.086$). Of the 210 participants, 128 were women (61%) and 82 men (39%). A chi-square test showed no significant sex differences between groups ($p = 0.215$).

At the beginning of the study, patients completed both the Roland–Morris Disability Questionnaire and the Oswestry Low Back Pain Disability Questionnaire, while the Roland–Morris Disability Questionnaire was completed again at the end of the study.

Devices Used in the Study

The following devices were used when administering therapy:

- ASV magnetotherapy device, model PMT Quattro PRO (ASA, Italy)
- ASV laser device, model MIX 5-04 (ASA, Italy)
- MedicalDevice EV 904 unit for electroanalgesic procedures and therapeutic ultrasound, model SONOPULS 591 (Enraf-Nonius B.V., Netherlands)
- Kinesiotherapy as a stand-alone physiotherapeutic method

Ethical Considerations

The study was conducted in accordance with all relevant guidelines to ensure appropriate research procedures and the safety of participants, following the principles of good clinical practice. The medical data used in the research were collected in line with bioethical standards, ensuring the privacy (medical confidentiality) of all participants and the protection of sensitive data.

The study fully respected the fundamental ethical and bioethical principles of personal integrity (autonomy, justice, beneficence and non-maleficence), in accordance with the Nuremberg Code, the latest revision of the Declaration of Helsinki and other relevant documents. All participants provided written informed consent before enrolment. The study was approved by the Ethics Committee of the University of Rijeka School of Medicine and the Ethics Committee of the Drinković Polyclinic in Zagreb.

Study Setting and Duration

The research was carried out at the Drinković Polyclinic in Zagreb, within the Department of Physical Medicine and Rehabilitation, ensuring standardised treatment conditions and a high level of professional expertise in administering therapy. A total of 210 participants—128 women (61%) and 82 men (39%), mean age 50.11 years (SD = 12.9)—were monitored. All participants had undergone detailed clinical and radiological evaluation confirming the diagnosis of chronic non-specific lumbar pain syndrome (CNLPS).

Each patient completed 10 treatment cycles over 10 days. Before participation, each individual provided written informed consent, ensuring compliance with ethical standards and transparency.

Primary and Secondary Objectives

The primary objective was to objectively compare the effectiveness of traditional passive physical therapies (such as electrotherapy, magnetotherapy, ultrasound, laser) with an integrated, combined approach in which kinesiotherapy—active therapeutic exercises aimed at strengthening and stabilising the trunk—was the central component.

Secondary objectives included assessment of symptom duration, the influence of demographic factors (age, sex), and the presence of radicular symptoms on treatment outcome.

Study Design and Participant Allocation

After initial evaluation and registration, all participants were randomly assigned to one of seven therapeutic groups to avoid selection bias:

- Group 1 (n = 30): received exclusively passive physical therapy, including 10-minute therapeutic ultrasound (depending on availability and clinical judgement).
- Group 2 (n = 30): received exclusively passive therapy, including 10-minute therapeutic laser.
- Group 3 (n = 30): received exclusively passive therapy, including 15-minute electroanalgesia.
- Group 4 (n = 30): received exclusively passive therapy, including 20-minute magnetotherapy.
- Group 5 (n = 30): received all passive modalities (ultrasound, laser, interferential currents and magnetotherapy), totalling 55 minutes per session.
- Group 6 (n = 30): in addition to all passive methods, patients also participated in daily, individually tailored kinesiotherapy sessions focused on the lumbar and lumbosacral region, lasting 75 minutes per session.
- Group 7 (n = 30): control group – patients without a diagnosis of CNLPS.

Treatment Protocol

Treatment lasted a total of 2 weeks. Each patient received five sessions per week, totalling 10 therapeutic treatments. Protocols were standardised but allowed for adjustment of intensity and exercise type based on physiotherapist assessment, patient health status and feedback.

Evaluation and Measurement Instruments

To objectively assess the effects of the applied therapies, the following validated questionnaires and tests were used:

- Roland–Morris Disability Questionnaire (RMDQ): assessment of functional ability and disability related to low back pain; completed at baseline and at the end of treatment.
- Oswestry Disability Index (ODI): additional evaluation of functional status at baseline.
- Visual Analogue Scale (VAS): subjective assessment of pain intensity.

Demographic data, symptom duration, presence of neurological deficits, radicular pain and additional clinical parameters relevant to the complexity of the syndrome were also collected.

Significance of the Methodology

The study was carefully designed with an emphasis on randomisation and procedure standardisation to minimise bias and enable valid comparison of outcomes. All data were analysed using statistical methods, including tests of significance between groups, multivariate analysis and the evaluation of clinically meaningful improvements.

Ultimately, this research provides not only answers regarding the effectiveness of individual physical therapy modalities, but also insight into the optimal therapeutic approach for LPS, taking into account the individual characteristics and needs of each patient.

7.2 Patient Stratification and Treatment Protocol

To achieve greater precision in assessing therapeutic outcomes and to avoid sample heterogeneity, patients were further stratified according to several key clinical criteria. In addition to general randomisation into the seven main therapeutic groups, stratification was based on symptom duration and the presence of radicular pain:

- Acute cases included patients whose symptoms had lasted less than 6 weeks. This group typically represents the initial phase of the condition, characterised by a pronounced inflammatory response and often rapid clinical improvement with conservative treatment.
- Subacute cases included patients with symptoms lasting between 6 and 12 weeks. These individuals have a higher risk of progressing to chronic pain if timely and targeted rehabilitation measures are not introduced.

- Chronic cases consisted of patients whose symptoms had persisted for more than 12 weeks. The clinical presentation is more complex, often accompanied by central and peripheral changes within the nervous system, psychosocial factors and a reduced quality of life.

In addition to symptom duration, special attention was given to the presence of radicular pain, such as in patients with clearly defined symptoms of sciatica or lumboradicular syndrome. Such patients require additional monitoring due to the potential for neurological deficits and longer recovery periods.

7.3 Treatment Protocols for All Groups

The meticulous design of this investigation into Chronic Non-Specific Low Back Pain (CNLPS) demanded a precise articulation of therapeutic interventions for each participant cohort. This section delineates the distinct protocols applied across seven groups, each constructed to isolate variables, explore synergistic effects, and ultimately, to advance the evidence base in musculoskeletal rehabilitation.

A foundational commitment to both standardization and individualized responsiveness guided the development of these protocols, recognizing the complex interplay between treatment fidelity and the patient's unique biological and psychosocial landscape.

I. Universal Protocol Elements for Active Intervention Groups (Groups 1-6)

For all participants allocated to an active therapeutic intervention (Groups 1 through 6), a consistent temporal and volumetric framework was rigorously applied:

- **Intervention Duration:** Each active treatment phase was structured over a period of **two (2) weeks**, providing a defined window for observing initial therapeutic responses and physiological adaptations.
- **Session Frequency:** A regimen of **five (5) dedicated sessions per week** was implemented, ensuring a sustained and consistent engagement with the prescribed modality or exercise program.
- **Total Therapeutic Encounters:** The cumulative exposure to therapeutic interventions amounted to **ten (10) individual sessions** per participant, providing ample opportunity for the hypothesized mechanisms of action to manifest.

Within this standardized framework, a crucial element of clinical adaptability was embedded. The administration of each physical therapy modality or kinesiotherapeutic exercise permitted nuanced adjustments in intensity, duration, and specific application

parameters. These modifications were dynamically informed by the supervising physiotherapist's expert assessment of the patient's evolving health status, subjective feedback regarding pain, comfort, and perceived exertion, as well as objective clinical progression. This adaptive mechanism was paramount for optimizing therapeutic engagement and ensuring patient safety while rigorously preserving the integrity of the core protocol. All treatments were meticulously documented, and patients were regularly evaluated to monitor potential side effects and therapeutic progress.

II. Delineated Treatment Protocols for Each Study Group

Group 1: Exclusive Therapeutic Ultrasound Protocol

This cohort was meticulously designed to isolate and quantify the singular efficacy of high-frequency mechanical vibration in the management of CNLPS. Participants received therapeutic ultrasound as their **sole** physical therapy intervention.

- **Primary Modality:** Therapeutic Ultrasound.
- **Session Duration:** Each therapeutic encounter consisted of a precisely timed **ten (10) minutes** of ultrasound application.
- **Clinical Rationale (Modality Application):** While assigned to this group randomly, the inherent properties of ultrasound—its capacity for thermal and non-thermal cellular effects, local micro-massage, and promotion of tissue healing—are traditionally applied in conditions characterized by myofascial syndromes, the presence of scar tissue, or post-traumatic inflammatory processes, all of which may contribute to the heterogeneous presentations of CNLPS.
- **Parameter Adjustment:** The specific application parameters (e.g., intensity in Watts per square centimeter (W/cm^2), frequency in Megahertz (MHz), and emission mode—pulsed or continuous wave) were calibrated by a qualified physiotherapist. This calibration was contingent upon the individual's precise anatomical targets, the depth of underlying tissue pathology, and the acute or chronic phase of the condition, with continuous re-evaluation based on the patient's symptomatic response and tissue tolerance.

Group 2: Exclusive Therapeutic Laser Protocol

This cohort was established to thoroughly investigate the isolated therapeutic impact of low-level laser therapy (LLLT) on CNLPS, probing its capacity for photobiomodulation at a cellular level. Participants underwent LLLT as their **exclusive** physical therapy intervention.

- **Primary Modality:** Low-Level Laser Therapy (LLLT).
- **Session Duration:** Each therapeutic session comprised a targeted **ten (10) minutes** of laser emission.
- **Clinical Rationale (Modality Application):** LLLT is recognized for its potential biostimulatory, anti-inflammatory, and analgesic properties, mediated through mechanisms such as enhanced ATP production and modulation of cellular signaling. Its application is particularly indicated in cases of tendinopathies, enthesopathies, or mild inflammatory processes, conditions frequently co-occurring with or contributing to CNLPS.
- **Parameter Adjustment:** The critical application parameters (e.g., wavelength in nanometers (nm), power output in milliwatts (mW), and energy density in Joules per square centimeter (J/cm^2)) were rigorously determined by clinical judgment. This determination was bespoke to the patient's specific tissue pathology, the precise localization of pain, and observed clinical progression, with continuous adaptation aimed at optimizing the therapeutic effect and ensuring energy delivery within the therapeutic window.

Group 3: Exclusive Electroanalgesia Protocol

This group was dedicated to assessing the discrete effects of electrical currents in modulating pain perception and influencing muscle activity within the context of CNLPS. Participants exclusively received electroanalgesia, utilizing techniques known for their capacity to interfere with nociceptive transmission pathways or induce muscle relaxation.

- **Primary Modality:** Electroanalgesia (e.g., Transcutaneous Electrical Nerve Stimulation - TENS, Interferential Currents, Diadynamic Currents).
- **Session Duration:** Each therapeutic session involved a **fifteen (15) minute** application of the chosen electrotherapeutic modality.
- **Clinical Rationale (Modality Application):** Electrotherapy, in its diverse forms, is a cornerstone for the management of acute pain, the alleviation of muscle spasms, and the treatment of neuropathic pain components, all of which are frequently encountered in the multifaceted presentations of CNLPS.
- **Parameter Adjustment:** The selection of the specific electrotherapeutic type (e.g., TENS for sensory modulation versus Interferential Currents for deeper tissue penetration) and the precise parameters (e.g., frequency in Hertz (Hz), pulse width in microseconds (μ s), and intensity in milliamperes (mA)) were critical clinical decisions. These were meticulously adjusted based on the patient's individual pain characteristics, the nature of associated muscle dysfunction, and their subjective comfort levels, with ongoing monitoring of both therapeutic efficacy and patient tolerance.

Group 4: Exclusive Magnetotherapy Protocol

This cohort aimed to elucidate the singular therapeutic contribution of pulsed electromagnetic fields to the comprehensive management of CNLPS. Participants exclusively received magnetotherapy, a modality recognized for its potential to influence cellular processes, promote tissue regeneration, and reduce inflammation.

- **Primary Modality:** Magnetotherapy.
- **Session Duration:** Each therapeutic session consisted of **twenty (20) minutes** of exposure to controlled magnetic fields.
- **Clinical Rationale (Modality Application):** Magnetotherapy is often strategically employed for patients presenting with chronic degenerative changes within the spinal structures or in situations where specific contraindications preclude the use of electrotherapy (e.g., presence of pacemakers), thereby offering a valuable alternative within the CNLPS therapeutic armamentarium.

- **Parameter Adjustment:** The crucial application parameters (e.g., magnetic field strength in Gauss or Tesla, and pulse frequency) were judiciously selected and adjusted by the supervising physiotherapist. This decision-making process took into account the patient's specific pathology (e.g., discopathy vs. osteoarthritic changes), the required depth of tissue penetration, and their individual physiological and symptomatic response to treatment.

Group 5: Combined Passive Modalities Protocol

This group represented a more traditional, multifaceted passive physical therapy approach, meticulously designed to explore the potential additive or synergistic benefits derived from the simultaneous application of multiple electrophysical agents.

- **Component Modalities:** A sequential application of all four specified passive physical therapies: Therapeutic Ultrasound, Therapeutic Laser, Electroanalgesia (specifically Interferential Currents), and Magnetotherapy.
- **Total Session Duration:** The combined application of these diverse modalities constituted approximately **fifty-five (55) minutes** per therapeutic session.
- **Interventional Philosophy:** Patients underwent a structured and systematic sequence of all four passive modalities within each session. The individual parameters for Ultrasound (10 minutes), Laser (10 minutes), Electroanalgesia (approximately 15 minutes, adjusted for optimal duration within the total session), and Magnetotherapy (20 minutes) were individually optimized in strict accordance with the principles and rationale outlined for Groups 1-4. This approach was tailored to each patient's evolving clinical picture and specific symptoms. This comprehensive passive strategy sought to maximize the pain-modulating, anti-inflammatory, and tissue-supportive effects achievable through a broad spectrum of electrophysical agents, hypothesizing a potentially superior outcome compared to single-modality interventions.

Group 6: Integrated Paradigm Protocol (Passive Modalities + Active Kinesiotherapy)

This cohort embodied the central, perhaps most ambitious, hypothesis of the study: that an integrated therapeutic paradigm, synthesizing the immediate symptomatic relief and tissue-priming effects of passive modalities with the fundamental functional restoration achieved through active exercise, offers the most efficacious and sustainable pathway for managing CNLPS.

- **Component Modalities & Duration:**
 - **Passive Modalities:** A comprehensive application of all four passive modalities (Ultrasound, Laser, Interferential Currents, Magnetotherapy), totaling approximately **fifty-five (55) minutes** per session, administered precisely as described for Group 5.
 - **Active Kinesiotherapy:** This passive phase was immediately followed by a dedicated **seventy-five (75) minutes** of individualized, meticulously supervised kinesiotherapy.
 - **Total Session Duration:** The integrated approach culminated in an approximate total session duration of **one hundred and thirty (130) minutes**.
- **Interventional Philosophy:** Participants in this group received the full spectrum of passive physical therapies, strategically employed to prepare tissues, reduce initial pain levels, and modulate inflammatory responses. This preparation was then leveraged to maximize engagement and benefit from the subsequent, foundational component of active, individualized kinesiotherapy. This kinesiotherapy program was exhaustively designed for comprehensive neuromusculoskeletal rehabilitation and included:
 - **Core Stabilization Exercises:** Focused strengthening of the deep trunk musculature (e.g., transversus abdominis, multifidus, pelvic floor),

progressively integrating more complex functional movements to enhance dynamic spinal stability and proprioceptive control.

- **Stretching and Mobilization Exercises:** Application of targeted static and dynamic stretching techniques for identified shortened or hypertonic muscles (e.g., hamstrings, hip flexors, piriformis), alongside manual and self-mobilization of joint and fascial structures to restore optimal range of motion, reduce stiffness, and address myofascial restrictions.
- **Progressive Loading of the Musculoskeletal System:** A carefully graded and individualized increase in exercise intensity, external resistance, and complexity, continuously adapted based on the patient's pain response, tolerance thresholds, and measurable progress in strength, endurance, and functional capacity.
- **Patient Education and Empowerment:** A paramount emphasis was placed on patient education, recognizing its indispensable role as a cornerstone of long-term self-management, adherence, and recurrence prevention:
 - **Ergonomics in Daily Activities:** Comprehensive instruction and practical demonstration on correct lifting techniques, optimal sitting and standing postures, safe load-carrying strategies, and active avoidance of movements or positions known to exacerbate symptoms or elevate the risk of re-injury.
 - **Postural Correction:** Individualized assessment of habitual postures and movement patterns, followed by tailored corrective strategies to address identified biomechanical imbalances and promote sustained ergonomic awareness in all activities of daily living.
 - **Recurrence Prevention Strategies:** Development of personalized long-term strategies, fostering self-efficacy through independent home exercise programs, and the cultivation of healthy lifestyle habits encompassing physical activity, stress management, and nutritional considerations.
- **Professional Oversight:** All kinesiotherapy sessions were conducted under the direct, continuous, and expert supervision of a university-trained physiotherapist (Master of Science in Physiotherapy). This highly qualified oversight ensured optimal

exercise execution, maintained participant motivation and adherence, and allowed for dynamic, real-time adaptation of the program based on immediate feedback and evolving clinical status. This meticulous supervision was deemed critical for maximizing safety and therapeutic efficacy, particularly for individuals presenting with higher risk profiles or potential adherence challenges.

Group 7: Control Cohort Protocol – Baseline Without CNLPS

This group served a critical methodological function, providing a robust normative baseline against which the physiological and functional impacts of CNLPS, and consequently the efficacy of the interventions in Groups 1-6, could be objectively and reliably evaluated.

- **Participant Characteristics:** This cohort was specifically comprised of individuals explicitly identified as being *without* a confirmed diagnosis of Chronic Non-Specific Low Back Pain (CNLPS) at the time of their recruitment and initial assessment.
- **Therapeutic Intervention:** Participants in this control group received **no therapeutic interventions** directly related to the study's focus on low back pain management. Their routine activities, health management practices, and lifestyle were not manipulated or altered by the study protocol.
- **Methodological Role:** The inclusion of this control group was purely for comparative purposes. It facilitated the establishment of typical baseline functional statuses, normative pain perception thresholds, and average demographic characteristics in the absence of the studied condition. This provision was essential for enabling a more precise and objective quantification of the magnitude of disability, pain intensity, and functional impairment experienced by the patient groups undergoing active interventions, thereby significantly enhancing the internal validity and interpretability of the research findings.

8

Functional Assessment Questionnaires

8.1 Roland–Morris Questionnaire / Roland–Morris Disability Questionnaire (RMDQ)

The Roland–Morris Disability Questionnaire (RMDQ) is among the most frequently used condition-specific instruments for assessing functional disability caused by low back pain. Developed in 1983, it arose from the need for a quick yet accurate measure of activity limitation—an aspect particularly important when evaluating treatment effectiveness across different therapeutic approaches (e.g. physical therapy, kinesiotherapy, pharmacotherapy).

Structure and Method of Completion

- The questionnaire consists of 24 clearly formulated statements, each reflecting one aspect of daily functioning that may be impaired due to back pain (examples include: “Because of my back pain, I lie down more often than usual,” “I find it difficult to climb stairs because of my back”).
- Completing the questionnaire requires no special preparation and takes only a few minutes. The patient circles or marks all statements that are true for them on that day—that is, those that best describe their current condition.
- The total number of marked statements constitutes the score, ranging from 0 (no functional limitation) to 24 (maximum disability).

- It is important to emphasise that the RMDQ is a self-assessment tool—the patient provides honest personal responses, which increases objectivity. When administered repeatedly, it allows accurate monitoring of rehabilitation progress or response to therapy.

Clinical Interpretation and Practical Application

- A score of 0–4 points indicates minimal or negligible limitations in daily activities, suggesting good functional status and the ability to live independently without major difficulties.
- Scores between 5 and 14 points indicate moderate functional limitations, where the patient clearly experiences difficulties with some tasks but is still able to perform most activities with certain adaptations or minor external assistance.
- A score of 15–24 points represents marked disability, with pronounced limitations and significant impact on quality of life, often requiring multidisciplinary care or support from others.
- One key strength of the RMDQ is its sensitivity to small changes: even a shift of a few points may indicate clinically significant improvement or deterioration, which is crucial for short-term and long-term monitoring of treatment outcomes.
- The RMDQ has been validated across multiple languages and healthcare systems, enabling international comparison of clinical research results and broad applicability in both routine practice and scientific studies.

Advantages and Limitations

- In addition to being simple and quick to administer, a major advantage is that it does not burden the patient and does not require specialised training for interpretation.
- However, one must consider potential subjective influences (such as mood, momentary pain intensity, motivation for recovery), which should be taken into account in the overall assessment of functional status.

8.2 Oswestry Questionnaire / Oswestry Low Back Pain Disability Questionnaire (OLBPDQ)

The Oswestry Disability Index (ODI) is the most comprehensive and internationally validated instrument for the quantitative assessment of disability and reduced quality of life caused by low back pain. Developed in 1980, this questionnaire has become an indispensable tool in the clinical practice of physiatrists, orthopaedic surgeons, neurosurgeons and physiotherapists, and is considered the gold standard in scientific research examining the effects of various treatments for lumbar pain syndromes.

Structure and Method of Administration

- The ODI consists of 10 thematic sections, each covering a key area of daily living:
 1. Back pain (intensity and frequency)
 2. Personal care (washing, showering, grooming)
 3. Lifting objects
 4. Walking
 5. Sitting
 6. Standing
 7. Sleeping
 8. Sexual life (where applicable)
 9. Social life and leisure activities
- Travelling and mobility outside the home
- In each section, the patient selects one of six possible responses (scored 0–5) that best describes their current level of limitation in that activity.
- The total score is the sum of all section scores (maximum 50 points). This value is then expressed as a percentage, enabling easy monitoring of improvement or deterioration over time, as well as comparison between patients or therapeutic groups.

Application and Clinical Value

- The ODI is suitable for all patients with acute, subacute or chronic low back pain, regardless of age, symptom severity or underlying cause.
- It is routinely used to evaluate the effectiveness of rehabilitation (e.g. physical therapy, kinesiotherapy) and post-surgical outcomes (e.g. discectomy, laminectomy).
- Its high sensitivity allows detection of even small clinically relevant changes in functional status, which is essential for timely adjustments to treatment.
- Practical advantages: completion requires only a few minutes, does not require specialist training, and the results are easily understood by both patients and clinicians.

Clinical Interpretation of Results

- 0–20%: minimal disability – most patients function well with minor adjustments; conservative management is usually sufficient.
- 21–40%: moderate disability – clear difficulties in daily activities; a structured rehabilitation programme and regular monitoring are required.
- 41–60%: severe disability – significant limitations; multidisciplinary management and additional support (psychological, social) are often necessary.
- 61–80%: very severe disability – marked loss of independence and quality of life, often accompanied by psychosocial consequences (anxiety, depression).
- 81–100%: complete disability – the patient is almost entirely dependent, often unable to function independently, and may be a candidate for invasive interventions or institutional care.

Advantages and Potential Limitations

- A major advantage of the ODI lies in its wide applicability and extensive validation across hundreds of clinical trials. When used together with other tools (e.g. RMDQ), it provides a comprehensive picture of the patient's condition.
- As with all self-report instruments, responses may be influenced by subjective factors; however, repeated administration and correlation with objective measures (clinical examination, functional tests) significantly enhance reliability.

8.3 Lasegue's test

The Lasègue test was performed on all patients.

The passive straight-leg-raise test is named after the French physician Charles Lasègue (1816–1883). The Lasègue test is a clinical examination used to confirm radicular pain of the sciatic nerve (L4–S1).

The straight-leg-raise test is performed with the patient lying in a supine position on the examination couch, with knees and hips extended. The examiner lifts the patient's straight leg, which must remain extended at the knee; the movement occurs only at the hip joint.

A healthy individual with no lumbosacral pain can raise the leg to 90 degrees without discomfort. The occurrence of pain between 30 and 70 degrees of elevation indicates significant tension or compression of the sciatic nerve, and the Lasègue test is then considered positive.

Raising the straight leg from 0 to 30 degrees does not stretch the sciatic nerve, while elevation beyond 70 degrees engages compensatory mechanisms of the hips and lumbar spine.

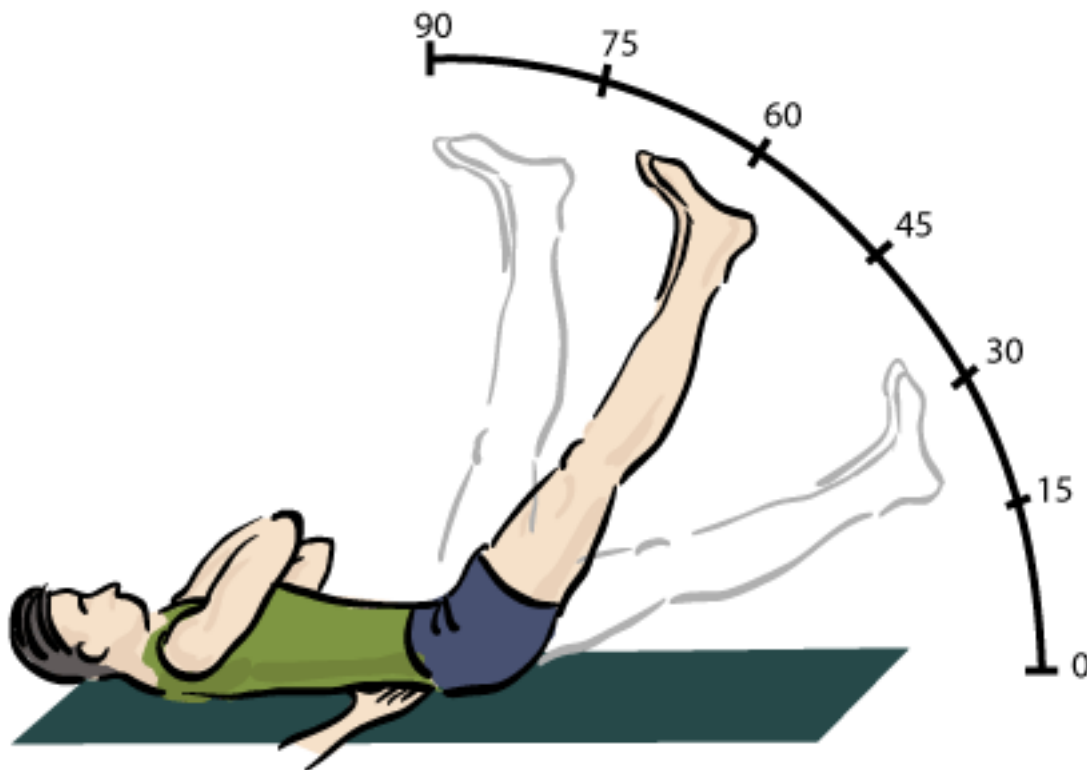


Figure 34. The Lasègue test

8.4 Tests for the range of motion of the lumbar spine

Evaluation of lumbar spine range of motion (ROM) is a core component of the musculoskeletal examination and provides clinically relevant information regarding spinal mobility, functional capacity, and potential sources of pain or impairment. Systematic assessment of lumbar ROM is routinely employed in orthopedic medicine, physical therapy, rehabilitation, sports medicine, and occupational health. When performed using standardized techniques, ROM testing contributes to diagnosis, baseline documentation, outcome monitoring, and treatment planning.

Anatomical and Biomechanical Considerations

The lumbar spine comprises five vertebrae (L1–L5) that are anatomically specialized for axial load transmission and mobility, predominantly in the sagittal plane. Flexion and extension account for the greatest proportion of lumbar motion, while lateral flexion and axial rotation are more restricted due to facet joint orientation, ligamentous restraints, and intervertebral disc structure. Lumbar motion occurs in conjunction with pelvic and hip movement; therefore, accurate assessment requires careful observation to distinguish true lumbar motion from compensatory movement patterns originating in adjacent regions.

General Principles of Lumbar Range of Motion Assessment

Lumbar ROM may be assessed actively or passively; however, active ROM is most commonly evaluated because it reflects functional movement capacity and neuromuscular control. The patient should be positioned consistently, with appropriate exposure to allow visualization of spinal landmarks. Clear instructions should be provided to minimize substitution and ensure reproducibility. In addition to the magnitude of motion, the examiner should document pain provocation, movement quality, symmetry, and end-range behavior.

Measurement techniques include visual estimation, tape-measure methods, goniometry, and inclinometry. Among these, inclinometry has demonstrated superior reliability and

validity for quantifying lumbar motion, particularly when segmental motion is isolated using dual-inclinometer techniques.

Lumbar Flexion

Lumbar flexion is typically assessed with the patient standing erect, feet positioned shoulder-width apart. The patient is instructed to bend forward to the maximal comfortable extent while keeping the knees extended. The examiner observes the reversal of lumbar lordosis, segmental smoothness, and the presence of pain, guarding, or asymmetry.

Quantitative assessment is commonly performed using the modified Schober test. A reference point is marked at the lumbosacral junction, often identified at the level of the posterior superior iliac spines, and a second point is marked 10 cm superior to this landmark. During maximal flexion, the increase in distance between the two points is measured. An increase of approximately 5 cm is generally considered within normal limits, whereas reduced excursion may indicate restricted lumbar mobility due to degenerative changes, disc pathology, inflammatory conditions, or pain-related inhibition.

Lumbar Extension

Assessment of lumbar extension is performed with the patient standing in a neutral position. The patient is instructed to extend the trunk posteriorly as far as possible while maintaining balance. Examiner support may be provided to prevent loss of stability. Observation focuses on the distribution of extension across the lumbar segments, as well as the presence of pain or apprehension.

Lumbar extension ROM can be quantified using dual inclinometers positioned at the T12 and S1 levels to isolate lumbar contribution. Pain or limitation during extension may be associated with facet joint arthropathy, spondylolysis, spinal stenosis, or posterior element involvement. Excessive reliance on hip extension rather than lumbar motion should be noted as a compensatory pattern.

Lumbar Lateral Flexion

Lumbar lateral flexion is assessed with the patient standing upright and the arms relaxed at the sides. The patient is instructed to bend laterally toward one side without trunk rotation or forward flexion. The examiner observes range, symmetry, and movement quality.

Measurement may be performed using an inclinometer or by measuring fingertip-to-floor distance before and after lateral bending. Normal lateral flexion is typically symmetrical. Unilateral restriction or pain may suggest muscular tightness, joint dysfunction, intervertebral disc involvement, or nerve root irritation.

Lumbar Rotation

Lumbar rotation is most accurately assessed in a seated position to minimize pelvic motion. The patient sits upright with the arms crossed over the chest and is instructed to rotate the trunk to each side. The examiner stabilizes the pelvis and observes the degree and quality of rotation.

True lumbar axial rotation is limited due to anatomical constraints; therefore, excessive apparent motion often reflects thoracic contribution. Although visual estimation is frequently used, inclinometers or goniometers may be employed for quantification. Pain, asymmetry, or restriction during rotation may be associated with disc pathology, facet joint disorders, or segmental instability.

Clinical Interpretation

Findings from lumbar ROM testing must be interpreted in conjunction with patient history, symptom presentation, neurological examination, strength testing, and functional

assessment. Isolated ROM deficits are not diagnostic but provide valuable information regarding movement impairment and mechanical behavior. Repeated ROM measurements over time are particularly useful for monitoring clinical progression and evaluating treatment outcomes.

In conclusion, systematic testing of lumbar spine range of motion is an essential element of comprehensive musculoskeletal evaluation. When conducted using standardized methods and interpreted within a broader clinical framework, lumbar ROM assessment offers meaningful insight into spinal function and dysfunction across diverse clinical disciplines.

8.5 Sagittal mobility index of the lumbar spine in research

There is no single rule, protocol or gold standard for measuring the range of motion of the lumbar spine. In most healthcare settings—hospitals, clinics and polyclinics—the index of sagittal mobility of the lumbar spine is the most commonly used method.

The procedure is performed by marking one line on the skin at the level of the L₅ vertebra, and a second line 10 cm above the first. The index of sagittal mobility is obtained by measuring flexion (inclination) and extension (reclination) relative to the initial neutral position.

On average, the value for flexion is 4–6 cm, while the average value for extension is 1.5 cm. The normal, optimal index of sagittal lumbar mobility ranges from 5.5 cm to 7.5 cm.

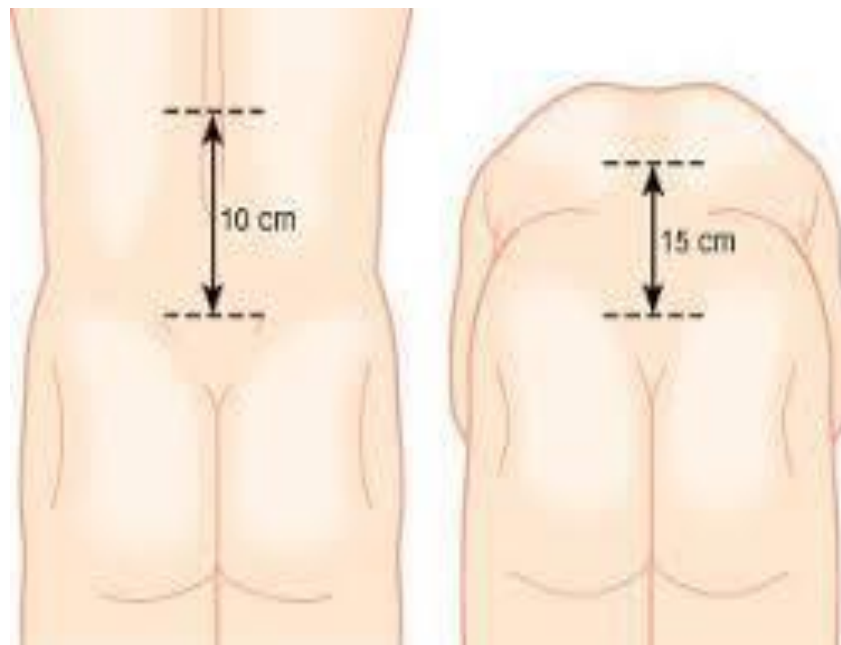


Figure 35. Schober's sagittal mobility index

8.6 Thomayer's measure in research

This test is performed with the patient standing in the neutral position, followed by trunk flexion (forward bending). The examiner then uses a measuring tape to record the distance between the tip of the middle finger and the floor. The result is known as the Thomayer measurement, or the finger-to-floor test.

Lateral flexion to the left and right is measured in the same way.

When measuring lateral trunk flexion, the measurement is taken as the distance between the highest point of the iliac crest and the point vertically aligned with it at the level of the junction between the trunk and the xiphoid process of the sternum.

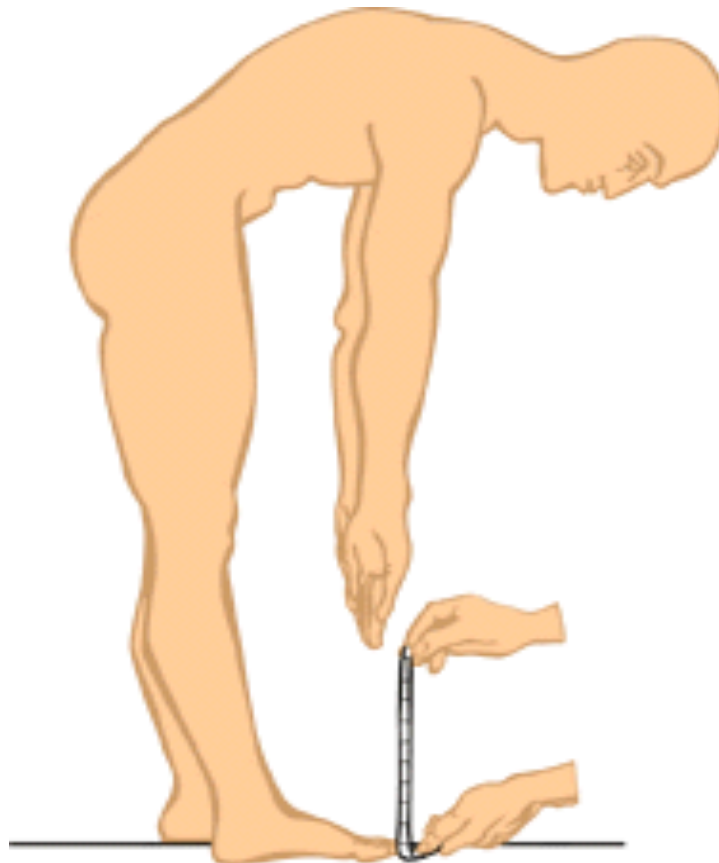


Figure 36. Finger-to-floor measurement

8.7 Lateral Flexion Test in research

The lateral flexion test is used to measure lateral mobility of the spine. Normal lateral flexion ranges from 20 to 30 degrees.



Figure 37. Demonstration of lateral flexion

9

Research Study Results

Following the completion of therapy, all groups demonstrated significant improvement in all treated patients. In every group, there was a statistically significant difference, $p < 0.05$ and $p \ll 0.001$, according to the post hoc Scheffé test for the total Roland–Morris Disability Questionnaire score. The results of the study indicate that combined therapy is the most effective for patients with lumbar pain syndrome. Specifically, there was no statistically significant difference between participants in Group 3 (electroanalgesia) and Group 4 (magnetotherapy), $p = 0.987$. Likewise, there was no statistically significant difference, $p = 0.999$, between participants who received individual laser therapy compared with ultrasound therapy. The tests used to measure the range of motion of the lumbar spine—the sagittal mobility index, the Lasègue test and the Thomayer measurement—also demonstrated improvements across all groups.

9.1 Statistical Analysis & Data Processing

The data were processed using the software package Statistica, version 13.5.0.17 (TIBCO Software Inc., USA). The data obtained through quantification were subjected to statistical analysis depending on the distribution of the results. Sample size estimation was performed using the Sample Size Calculation module in Statistica. The minimum required group size was calculated with $\alpha = 0.05$ and a statistical power of 80%, which is the customary standard. Participants were allocated into seven groups; for a linear region of the root mean squared standard error (RMSSE) of 0.3 to 0.5, the recommended sample size was 27 participants. We therefore included 30 participants per group. Statistical significance was assessed at the $p \leq 0.05$ level, with 95% confidence intervals. Descriptive statistics were used to summarise the data, including calculation of the arithmetic mean, standard deviation, mode, and the 25th and 75th percentiles. For the Lasègue test, the results were presented as frequencies of occurrence. To examine differences in mean scores before and after therapy, one-way ANOVA was used, as the data followed a normal distribution. Normality was tested using the Kolmogorov–Smirnov test. Among the post hoc procedures, the Scheffé test was applied. The reliability of the measurement questionnaires was assessed by calculating Cronbach's alpha coefficients, including estimation of how the coefficient would change if individual items were removed from their respective scales.

To ensure an objective and scientifically grounded assessment of the effectiveness of different therapeutic protocols in patients with lumbar pain syndrome, a comprehensive statistical analysis of all collected data was carried out, with strict adherence to the principles of biostatistics and medical research methodology.

Methodological framework and choice of statistical tools

- All numerical data were analysed using descriptive statistics: arithmetic means, standard deviations, medians, and ranges (minimum–maximum) were calculated, providing insight into the basic distribution, variability and central tendencies of each examined parameter (e.g. RMDQ, ODI, VAS scores before and after therapy).
- To assess treatment effectiveness within each group, a paired t-test was used, comparing scores before and after the therapeutic cycle for the same participants.
- To compare results between different groups, an unpaired t-test was employed, determining potential differences in therapeutic outcomes between groups receiving different treatment approaches.

- The χ^2 test (chi-square) was applied to categorical variables, for example when analysing the presence or absence of radicular symptoms, sex distribution, acuity of pain, and other demographic characteristics.
- In cases where comparison of more than two groups or variables was required (e.g. symptom duration categories: acute, subacute, chronic), a one-way analysis of variance (ANOVA) was used, followed by post hoc testing to precisely identify the sources of statistical differences.

Thresholds for statistical significance and interpretation of results

- Results were considered statistically significant if the p-value was less than 0.05 ($p < 0.05$), indicating that the probability of the outcome occurring by chance was below 5%.
- In instances where differences were even more pronounced ($p < 0.01$), they were classified as highly significant, further strengthening the validity of the therapeutic effect.

Advanced analysis and key findings

- For visual presentation of the results, graphical methods (bar and line charts) were used to clearly illustrate improvements in questionnaire scores (RMDQ, ODI, VAS) throughout the therapeutic cycle.
- All treatment groups demonstrated statistically significant improvements in all functional and subjective parameters after completing the intervention.
- Notably, Group 6, which received structured kinesitherapy in addition to passive physical modalities, achieved markedly greater improvement, confirmed across all relevant outcome measures.
- Subgroup analyses (acute, subacute and chronic patients; presence or absence of radicular pain) revealed that the combined approach was particularly effective in chronic and radicular forms of lumbar pain syndrome.
- Based on these findings, the study emphasises the importance of an individualised, active and multimodal approach to rehabilitation, with a recommendation for broad implementation of such protocols in routine clinical practice.

9.2 Results of the Disability Questionnaire

The Oswestry Low Back Disability Questionnaire covers ten domains – pain intensity, personal care (such as washing and dressing), lifting, walking, sitting, standing, sleeping, sexual life, social life and travelling. Each domain contains six possible responses, scored from 0 to 5. The maximum score is 50, with higher values indicating greater disability caused by back pain.

Participants completed the Oswestry Disability Questionnaire only at the beginning of the therapy programme. Table 2 presents the number of participants who selected each answer, together with corresponding percentages.

Table 2. Scores on the Disability Questionnaire

Disability Questionnaire	0	%	1	%	2	%	3	%	4	%	5	%
1. Pain intensity	67	31.9	44	21	23	10.9	46	21.9	22	10.5	8	3.8
2. Personal care	79	37.6	89	42.4	31	14.8	9	4.3	1	0.5	1	0.5
3. Lifting	38	18.1	81	38.6	63	30	14	4.5	12	5.7	2	1
4. Walking	67	31.9	83	39.5	36	17.1	19	9	4	1.9	1	0.5
5. Sitting	58	27.6	60	28.6	60	28.6	20	9.5	8	3.8	4	1.9
6. Standing	45	21.4	64	30.5	61	29	17	8.1	21	10	2	1
7. Sleeping	76	36.2	73	34.8	44	21	7	3.3	6	2.9	4	1.9
8. Sexual life	92	43.8	44	21	26	12.4	22	10.5	15	7.1	11	5.2
9. Social life	58	27.6	72	34.3	35	16.7	27	12.8	15	7.1	3	1.4
10. Travelling	54	25.7	75	35.7	56	26.7	10	4.8	4	1.9	11	5.2

Interpretation of the Results

Table 3 shows the results relating to pain intensity. It is evident that 31.9% of participants can tolerate pain without analgesics. A further 21% experience severe pain but do not take analgesics, while 10.9% report complete relief with analgesics.

Analgesics provide only moderate pain reduction in 21.9%, and very little benefit in 10.5% of participants. Only 3.8% of participants do not use analgesics at all.

Regarding personal care, the largest proportion of participants (37.6%) report no difficulties. In addition, 42.4% are able to look after themselves but doing so causes pain. A total of 14.8%

experience slow and painful self-care, while 4.8% require assistance. Only 0.5% require daily help and cannot carry out personal care independently.

When assessing lifting, only 18.1% can lift heavy objects without pain. The highest proportion (38.6%) can lift heavy objects but with pain, while 5.7% can lift only very light items.

Difficulties with walking any distance were reported by 31.9% of participants. A further 39.5% experience pain that prevents them from walking more than 1 km. Only 1.9% can walk only with the help of a cane or crutch.

For sitting, 27.6% can sit on any chair for as long as they wish. Almost the same proportion (28.6%) can sit in their favourite chair but not for more than one hour, while 1.9% are unable to sit due to pain.

Regarding standing, 21.4% can stand for as long as they wish without pain. The largest proportion (30.5%) can stand but with discomfort, while 29% cannot stand for longer than one hour. A further 10% cannot stand for more than 10 minutes.

In the sleeping domain, 36.2% report that pain does not disturb their sleep, and 34.8% can fall asleep without medication. However, 21% require tablets and sleep fewer than six hours, and 1.9% are unable to sleep due to pain.

Regarding sexual life, 43.8% report normal sexual function without pain. Pain during intercourse is reported by 21%, and 5.2% are prevented from sexual activity or travelling due to pain.

In terms of social life, 27.6% report a normal social life without pain; 34.3% maintain normal social interactions but with increased pain. Pain restricts social activities in 12.8%, and 1.4% have no social life due to pain.

Finally, with regard to travelling, 25.7% experience no pain during travel. A further 35.7% can travel despite pain, while 26.7% experience pain but can still travel for more than two hours.

9.3 Degree of disability

To assess disability, it is necessary to sum the points from all ten domains, as shown in Table 4.

Table 4. Degree of Disability

Percentage	Points	Disability Level	Number of Participants
0–20%	0–10	Minimal	79
21–40%	11–20	Moderate	85
41–60%	21–30	Severe	40
61–80%	31–40	Disabled	5
81–100%	41–50	Bed-bound	1

From Table 4 it is evident that 78.1% of participants have minimal or moderate disability, while 19% were found to have severe disability.

9.4 ANOVA test

The groups were defined according to the type of therapy administered. The ANOVA test showed that there is a significant difference among the groups ($F = 13.23$, $p << 0.001$). A post hoc Scheffé test was performed to examine differences between each pair of groups.

Table 5. Significance Levels Between Groups in the Post Hoc Scheffé Test

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Group 1		1.000	0.990	1.000	1.000	1.000	0.000
Group 2	1.000		0.982	1.000	1.000	1.000	0.000
Group 3	0.990	0.982		0.999	0.954	0.995	0.000
Group 4	1.000	1.000	0.999		0.998	1.000	0.000

Group 5	1.000	1.000	0.954	0.998		1.000	0.000
Group 6	1.000	1.000	0.995	1.000	1.000		0.000
Group 7	0.000	0.000	0.000	0.000	0.000	0.000	

From Table 5, it is evident that Groups 1 to 6 differ significantly from Group 7, as the control group has $p < 0.001$. There is no statistically significant difference between Groups 1 to 6.

9.5 Low Back Pain Questionnaire

The Roland–Morris Disability Questionnaire was completed by the participants at the beginning and at the end of therapy. The questionnaire consists of 24 statements covering various activities of daily living. Each statement is scored as 0 (the answer is “no”) or 1 (the answer is “yes”), where a higher score indicates a greater level of disability. The maximum possible score is 24. The table below presents the responses for each item.

Table 6. Comparison of Individual Items in the Roland–Morris Questionnaire

#	Item	Before		Before		P
		Yes	No	Yes	No	
1.	Because of my back pain, I stay at home most of the day.	36	174	14	196	<0.001
2.	I change position frequently in an attempt to get my back comfortable.	93	117	49	161	<0.001
3.	Because of my back pain, I walk more slowly than usual.	105	105	87	123	0.078
4.	Because of my back pain, I do not do any of the jobs I usually do around the house.	40	170	26	184	0.060
5.	Because of my back pain, I use a handrail when going upstairs.	67	143	50	160	0.064
6.	Because of my back pain, I lie down more often to rest.	67	143	38	172	<0.001
7.	Because of my back pain, I have to hold on to something to get out of an armchair.	46	164	31	179	0.058
8.	Because of my back pain, I ask other people to do things for me.	47	163	31	179	0.044
9.	Because of my back pain, I get dressed more slowly than usual.	86	124	53	157	<0.001

10.	Because of my back pain, I only stand for short periods.	50	160	37	173	0.118
11.	Because of my back pain, I try not to bend or kneel.	108	102	92	118	0.118
12.	Because of my back pain, it is difficult for me to get up from a chair.	38	172	31	179	0.356
13.	My back is painful most of the time.	56	154	29	181	0.001
14.	Because of my back pain, it is difficult for me to turn over in bed.	47	163	29	181	0.020
15.	Because of my back pain, I have a poor appetite.	23	187	9	201	0.010
16.	Because of my back pain, I find it difficult to put on my socks.	83	127	52	158	0.001
17.	Because of my back pain, I only walk short distances.	61	149	32	178	<0.001
18.	Because of my back pain, I sleep less than usual.	53	157	33	177	0.016
19.	Because of my back pain, I get dressed with someone's help.	10	200	10	200	1.00
20.	Because of my back pain, I spend most of the day sitting.	22	188	20	190	0.745
21.	Because of my back pain, I avoid heavy jobs around the house.	123	87	119	91	0.692
22.	Because of my back pain, I am more irritable and bad-tempered with people than usual.	63	147	44	166	0.033
23.	Because of my back pain, I go upstairs more slowly than usual.	90	120	63	147	0.007
24.	Because of my back pain, I stay in bed most of the day.	12	198	6	204	0.148

Each question in Table 6 was analysed using the chi-square test because the data come from dependent samples. There is a statistically significant difference before and after therapy in items 1, 2, 6, 8, 9, 13, 14, 15, 16, 17, 18, 22, and 23. For items 3, 4, 5, 7, 10, 11, 12, 19, 20, 21, and 24, there is no significant difference compared with pre-therapy responses, indicating that the results after therapy are better than those before therapy.

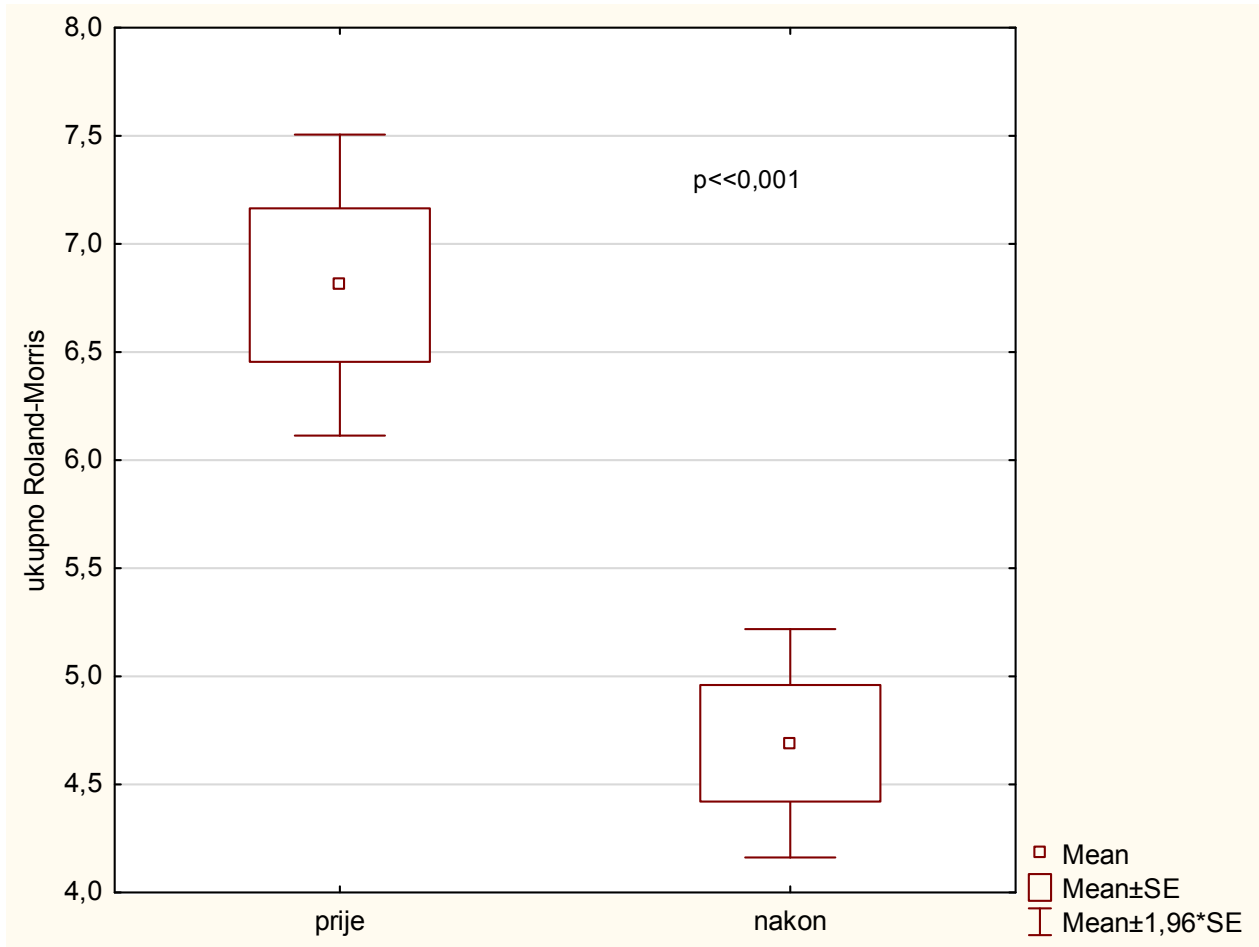


Figure 38. Level of Disability Expressed in Points from the Roland–Morris Questionnaire

Figure 38 shows the total score based on all 24 statements. It can be observed that the scores follow a normal distribution, which allowed the use of the difference method (Student's t-test for paired samples) to examine changes before and after therapy. The figure clearly demonstrates that the level of disability is significantly lower after therapy ($p < 0.001$).

9.6 Non-Parametric Wilcoxon Test

Since the variables used to assess the range of motion of the lumbar spine (sagittal mobility index, anteflexion, left and right lateral flexion) are not distributed in accordance with a normal distribution when comparing the values before (B) and after (A) therapy, the non-parametric Wilcoxon matched-pairs test was used. In the presentation, the median was used as the measure of central tendency, and the 25th and 75th percentiles as measures of variability. For the Lasègue test, the data are qualitative, so the frequency of occurrence was presented. Differences were tested using the chi-square test. The results are shown in Table 7.

Table 7. Comparison Before and After Therapy

N = 210	Median	25th percentile	75th percentile	p
Sagittal mobility index				
B	4.5	4	5	<0.001
A	5	5	5	
Anteflexion				
B	18	9	25	<0.001
A	16	7	23	
Left lateral flexion				
B	41	34	46	<0.001
A	39	32	44	
Right lateral flexion				
B	43	36	48	<0.001
A	41	33	45	
Lasègue test	0	1	Chi-square	
B	49	161	164.9	<<0.001
A	181	29		

From Table 7 it is evident that the values in all tests measuring lumbar spine range of motion improved significantly after therapy. For the sagittal mobility index, anteflexion, and left and right lateral flexion, $p < 0.001$. The Lasègue test also shows a statistically significant difference before and

after therapy ($p \ll 0.001$): before therapy, 161 patients had a positive test, whereas after therapy only 29 patients remained positive, indicating an improvement of 55%.

9.7 Differences in Scores Before and After Therapy

For the total Roland–Morris Questionnaire score, as well as for all tests measuring lumbar spine range of motion (SMI, anteflexion, left and right lateral flexion), we calculated the difference in scores after and before therapy for each participant. Table 8 presents the descriptive data for the whole sample ($N = 210$). Mean, median, standard deviation, and 25th and 75th percentiles are shown.

Table 8. Descriptive Data for the Differences

Difference Before and After	Mean	Median	25th percentile	75th percentile	Standard deviation
Total RM	2.11	2	0	4	2.71
SMI	0.47	0.5	0	1	0.56
Anteflexion	1.76	2	1	2	1.13
Left lateral flexion	1.99	2	1	2	0.96
Right lateral flexion	2.10	2	2	3	1.01

Table 8 shows the mean, median, standard deviation, and 25th and 75th percentiles. The mean values are as follows: total RM 2.11, SMI 0.47, anteflexion 1.76, and the results for left and right lateral flexion are similar, 1.99 and 2.10 respectively.

As the participants were divided into seven groups according to the type of therapy applied, the following tables provide descriptive data for each group.

Table 9. Ultrasound Therapy – Differences

Group 1 ($N = 30$), Measure	Mean	Median	25th percentile	75th percentile	SD
Total RM	3.13	2	0	4	3.36
SMI	0.62	1	0	1	0.08
Anteflexion	1.63	2	1	2	1.62

Left lateral flexion	1.98	2	2	2	0.72
Right lateral flexion	2.00	2	2	2	0.69
Lasègue test					
Before: 3 positive / 27 negative					
After: 22 negative / 8 positive					

Group 1 (ultrasound therapy) showed improvement in all observed parameters. In the Lasègue test, 19 out of 30 patients no longer experienced pain after therapy, showing an improvement of 33%.

Table 10. Laser Therapy – Differences

Group 2 (N = 30), Measure	Mean	Median	25th percentile	75th percentile	SD
Total RM	2.97	3	3	4	2.11
SMI	0.65	1	0	1	0.48
Anteflexion	1.87	2	1	2	1.08
Left lateral flexion	1.73	2	1	2	0.69
Right lateral flexion	1.93	2	2	2	0.98
Lasègue test					
Before: 3 positive / 27 negative					
After: 26 negative / 4 positive					

Improvement was observed in all mobility measures. The Lasègue test improved in 23 patients—67% had no pain on testing.

Table 11. Electroanalgesia – Differences

Group 3 (N = 30), Measure	Mean	Median	25th percentile	75th percentile	SD
Total RM	1.10	1	0	3	2.41
SMI	-0.05	0	-0.5	0.5	0.67
Anteflexion	2.46	3	2	4	1.41

Left lateral flexion	2.53	2	2	3	1.43
Right lateral flexion	2.73	3	2	4	1.43
Lasègue test					
Before: 11 positive / 19 negative					
After: 22 negative / 8 positive					

All mobility parameters improved except the SMI, which showed a slight negative shift. Lasègue improvement was seen in 11 patients (23%).

Table 12. Magnetotherapy – Differences

Group 4 (N = 30), Measure	Mean	Median	25th percentile	75th percentile	SD
Total RM	0.53	0	-1	2	2.39
SMI	0.38	0	0	0.5	0.50
Anteflexion	1.43	2	1	2	1.01
Left lateral flexion	2.05	2	1	3	1.05
Right lateral flexion	1.91	2	1	2	0.79
Lasègue test					
Before: 5 positive / 25 negative					
After: 26 negative / 4 positive					

Improvements were observed in all measures. Lasègue improvement was 62.5%.

Table 13. Combination of All Physiotherapy Modalities – Differences

Group 5 (N = 30), Measure	Mean	Median	25th percentile	75th percentile	SD
Total RM	1.87	2	1	2	0.82
SMI	0.70	1	0.5	1	0.43
Anteflexion	1.77	2	1	2	1.13

Left lateral flexion	2.10	2	2	3	0.84
Right lateral flexion	2.10	2	2	3	1.12
Lasègue test					
Before: 7 positive / 23 negative					
After: 25 negative / 5 positive					

Eighteen patients experienced resolution of Lasègue positivity (46% improvement).

Table 14. Combination of Physiotherapy + Kinesitherapy – Differences

Group 6 (N = 30), Measure	Mean	Median	25th percentile	75th percentile	SD
Total RM	5.03	4	3	6	2.68
SMI	0.23	0	0	1	0.61
Anteflexion	1.63	2	1	2	1.07
Left lateral flexion	1.70	2	1	2	0.70
Right lateral flexion	2.08	2	2	2	0.85
Lasègue test					
Before: 7 positive / 23 negative					
After: 30 negative / 0 positive					

This group had the most pronounced improvements. The mean RM improvement of 5.03 is substantial. After therapy, no participant experienced pain on Lasègue testing.

Table 15. Control Group – Differences

Group 7 (N = 30), Measure	Mean	Median	25th percentile	75th percentile	SD
Total RM	0.20	0	0	0	0.66
SMI	0.75	1	0.5	1	0.41
Anteflexion	1.53	1.5	1	2	1.10

Left lateral flexion	1.87	2	1	2	0.86
Right lateral flexion	1.97	2	1	2	0.93
Lasègue test					
Before: 13 positive / 17 negative					
After: 30 negative / 0 positive					

This group contained patients without CNSLBS. Although these patients did not have low-back-related diagnoses, the prescribed therapies eliminated Lasègue positivity in all cases by the end of treatment.

9.8 One-Way Analysis of Variance

In this study, we examined whether a significant difference existed between the seven observed groups. As the groups represented independent samples, a one-way analysis of variance (ANOVA) was applied. The assumptions of normality and homogeneity of variance were met. Table 16 presents the F-statistics and levels of statistical significance.

Table 16. Results of the One-Way Analysis of Variance

	F	p
Total RM	17.59	<<0.001
SMI	9.76	<<0.001
Anteflexion	2.90	0.010
Left lateral flexion	2.73	0.014
Right lateral flexion	2.48	0.024

The analysis of variance shown in Table 16 indicates that there is a significant difference between all observed groups for the total RM score, the sagittal mobility index, anteflexion, and left and right lateral flexion.

A particularly marked statistically significant difference is observed for the total RM score and the sagittal mobility index, where $p < 0.001$.

9.9 Post-hoc Scheffé Test

To determine whether a significant difference occurred between any two groups, a post hoc Scheffé test was performed (Table 17). The following table presents the levels of statistical significance between the individual groups.

Table 17. Levels of Statistical Significance in the Post-Hoc Scheffé Test for the Total RM Score

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Group 1	—	1.000	0.058	0.003	0.567	0.099	0.000
Group 2	1.000	—	0.112	0.008	0.725	0.050	0.001
Group 3	0.058	0.112	—	0.987	0.939	0.000	0.874
Group 4	0.003	0.008	0.987	—	0.502	0.000	0.999
Group 5	0.567	0.725	0.939	0.502	—	0.000	0.219
Group 6	0.099	0.050	0.000	0.000	0.000	—	0.000
Group 7	0.000	0.001	0.874	0.999	0.219	0.000	—

From Table 17, we compared all seven groups to determine statistical significance for the total RM score. Statistically significant differences exist between Group 1 (ultrasound) and Group 4 (magnetotherapy) for the total RM score ($p < 0.003$), with Group 1 showing better results.

Group 2 (laser) also differs significantly from Group 4 (magnetotherapy) for the total RM score ($p < 0.008$).

Group 7 (control group) shows statistically significant differences compared with Group 2 (laser), with $p < 0.001$.

Group 6 received combined therapy with kinesitherapy. This group demonstrated the greatest improvement between the beginning and end of therapy and differed significantly from all other groups for the total RM score.

Group 6 differs significantly from Group 2 (laser), with $p < 0.050$.

Group 6 also differs significantly from Group 3 (electroanalgesia), Group 4 (magnetotherapy), and Group 5 (combined physiotherapy procedures), with $p << 0.001$.

The difference between Group 1 and Group 6 is statistically non-significant for the total RM score ($p < 0.099$).

Sagittal Mobility Index (SMI / ISG)

Table 18. Levels of Statistical Significance in the Post-Hoc Scheffé Test for the Sagittal Mobility Index

	G1	G2	G3	G4	G5	G6	G7
G1	—	1.000	0.001	0.799	0.999	0.223	0.985
G2	1.000	—	0.000	0.675	1.000	0.140	0.997
G3	0.001	0.000	—	0.108	0.000	0.606	0.000
G4	0.799	0.675	0.108	—	0.465	0.973	0.275
G5	0.999	1.000	0.000	0.465	—	0.061	1.000
G6	0.223	0.140	0.606	0.973	0.061	—	0.023
G7	0.985	0.997	0.000	0.275	1.000	0.023	—

Table 18 shows the statistical significance levels for the sagittal mobility index.

There is a statistically significant difference between Group 1 (ultrasound) and Group 3 (electroanalgesia) in favour of Group 1 ($p < 0.001$).

Group 2 (laser) also shows significantly better results than Group 3 (electroanalgesia) ($p << 0.001$).

Group 5 (combined physiotherapy procedures) differs significantly from Group 3 (electroanalgesia) ($p << 0.001$).

Group 7 (control group) has, on average, better sagittal mobility scores than Group 3 ($p << 0.001$).

There is no statistically significant difference between Group 6 (combined procedures with kinesitherapy) and Group 7 (control group) for the sagittal mobility index ($p = 0.023$).

Anteflexion

Table 19. Levels of Statistical Significance in the Post-Hoc Scheffé Test for Anteflexion

	G1	G2	G3	G4	G5	G6	G7
G1	—	0.995	0.202	0.998	1.000	1.000	1.000
G2	0.995	—	0.614	0.886	1.000	0.995	0.967
G3	0.202	0.614	—	0.043	0.417	0.202	0.100
G4	0.998	0.886	0.043	—	0.967	0.998	1.000
G5	1.000	1.000	0.417	0.967	—	1.000	0.995
G6	1.000	0.995	0.202	0.998	1.000	—	1.000
G7	1.000	0.967	0.100	1.000	0.995	1.000	—

Table 19 shows statistically significant differences for anteflexion.

Only one significant difference was identified: between Group 3 (electroanalgesia) and Group 4 (magnetotherapy), in favour of Group 4 ($p = 0.043$).

Left Lateral Flexion

Table 20. Levels of Statistical Significance in the Post-Hoc Scheffé Test for Left Lateral Flexion

	G1	G2	G3	G4	G5	G6	G7
G1	—	0.982	0.521	1.000	1.000	0.967	1.000
G2	0.982	—	0.094	0.943	0.888	1.000	0.999
G3	0.521	0.094	—	0.675	0.779	0.069	0.271
G4	1.000	0.943	0.675	—	1.000	0.909	0.997
G5	1.000	0.888	0.779	1.000	—	0.839	0.988
G6	0.967	1.000	0.069	0.909	0.839	—	0.998
G7	1.000	0.999	0.271	0.997	0.988	0.998	—

Table 20 shows no statistically significant differences among the groups.

For left lateral flexion, no significant effects were found based on therapy type.

Right Lateral Flexion

Table 21. Levels of Statistical Significance in the Post-Hoc Scheffé Test for Right Lateral Flexion

	G1	G2	G3	G4	G5	G6	G7
G1	—	1.000	0.232	1.000	1.000	1.000	1.000
G2	1.000	—	0.143	1.000	0.999	0.999	1.000
G3	0.232	0.143	—	0.125	0.416	0.382	0.184
G4	1.000	1.000	0.125	—	0.998	0.999	1.000
G5	1.000	0.999	0.416	0.998	—	1.000	1.000
G6	1.000	0.999	0.382	0.999	1.000	—	1.000
G7	1.000	1.000	0.184	1.000	1.000	1.000	—

In Table 21, no statistically significant differences were found among the groups.

For right lateral flexion, the therapy type did not influence the outcomes significantly.

9.10 Chi-Square Test for Lasegue's Test

A chi-square test was used to examine the difference in the frequencies of responses 0 and 1 before and after therapy for each group. Table 22 shows that after therapy there was a significantly higher frequency of 0.

Table 22. Levels of Statistical Significance Obtained Using the Chi-Square Test

Lasègue Test Results	0	1	Chi-square	P
Group 1 Before	3	27	22.21	<<0.001
After	22	8		
Group 2 Before	3	27	32.30	<<0.001
After	26	4		
Group 3 Before	11	19	6.73	0.009
After	22	8		
Group 4 Before	5	25	26.69	<<0.001

After	26	4		
Group 5 Before	7	23	19.35	<<0.001
After	25	5		
Group 6 Before	7	23	34.12	<<0.001
After	30	0		
Group 7 Before	13	17	21.01	<<0.001
After	30	0		

In Table 22, the results of the Lasègue test show that there is a statistically significant difference between the beginning and the end of therapy in all groups.

The best results were observed in Group 6 (combined physiotherapy procedures with kinesitherapy), with $p < 0.001$, where 23 participants who were previously positive became negative.

The smallest improvement was recorded in Group 3 (electroanalgesia), with $p = 0.009$, where 11 participants showed improvement.

9.11 Comparison of All Seven Treatment Groups

The intricate labyrinth of chronic non-specific low back pain (CNLPS) demands not merely intervention, but a discerning inquiry into the comparative efficacy of therapeutic modalities. This chapter embarks upon a rigorous comparative analysis of the seven distinct treatment protocols delineated in the preceding sections, each designed to illuminate specific facets of rehabilitation science. By contrasting these diverse approaches, from isolated passive interventions to integrated active engagement, this investigation endeavors to provide a foundational understanding for optimizing clinical practice and informing a more nuanced, evidence-based therapeutic philosophy.

The methodological rigor embedded within the study's design—encompassing meticulous randomization, comprehensive patient stratification, and standardized treatment delivery—serves as the bedrock upon which meaningful comparisons can be constructed. These

deliberate structural choices mitigate potential biases, thereby elevating the interpretability and generalizability of the ensuing findings. Each of the seven groups represents a distinct hypothesis regarding the most effective pathway to alleviating pain, restoring function, and enhancing the overall quality of life for individuals grappling with the pervasive challenge of CNLPS.

I. The Reductionist Lens: Isolated Passive Modalities (Groups 1-4)

The initial quartet of treatment groups (Groups 1-4) collectively represents a reductionist philosophical approach, isolating individual passive physical therapy modalities to ascertain their discrete therapeutic contributions. This strategy is rooted in the tradition of mechanistic inquiry, seeking to understand the unique physiological and symptomatic effects attributable to a single form of energy or stimulation.

- **Group 1 (Therapeutic Ultrasound):** This protocol examines the singular impact of high-frequency mechanical waves, posited to influence cellular activity, tissue extensibility, and local circulation. The comparison here will probe whether this localized, micro-mechanical intervention alone is sufficient to induce significant clinical improvement in a complex pain syndrome.
- **Group 2 (Therapeutic Laser):** Focusing on photobiomodulation, this group evaluates the capacity of coherent light energy to exert anti-inflammatory, analgesic, and biostimulatory effects at a cellular level. The comparison will critically assess the intrinsic value of low-level laser therapy when divorced from other interventions, asking if subtle cellular modulation translates to macro-level clinical change.
- **Group 3 (Electroanalgesia):** Through the application of electrical currents, this protocol investigates the neuromodulatory potential of electrotherapy in pain perception and muscle function. The comparison seeks to quantify the efficacy of exogenous electrical stimulation in interrupting pain pathways and alleviating muscle spasm, questioning the long-term impact of primarily symptomatic relief.
- **Group 4 (Magnetotherapy):** This group probes the influence of pulsed electromagnetic fields on cellular processes, tissue repair, and pain. The comparison will explore whether the bio-physical effects of magnetic therapy, often considered for

conditions with degenerative components, yield distinct advantages or equivalent outcomes to other passive modalities.

Collectively, these four groups serve as crucial benchmarks. Their comparative analysis allows for the differentiation of specific mechanistic effects, providing insight into which forms of passive energy delivery might offer superior targeted symptomatic relief.

Philosophically, they represent interventions administered **to** the patient, with a primary focus on biological tissue response and pain signal modification, often without overt patient engagement in the therapeutic process beyond reception.

II. The Cumulative Paradigm: Combined Passive Modalities (Group 5)

Group 5 represents a departure from the singular focus, embracing a more eclectic, albeit still passive, approach. By amalgamating all four passive modalities—ultrasound, laser, electroanalgesia, and magnetotherapy—this protocol tests the hypothesis of additive or synergistic effects.

- **Group 5 (Combined Passive Modalities):** This protocol investigates whether the simultaneous or sequential application of a broader spectrum of passive energies provides a more comprehensive symptomatic amelioration than any single modality in isolation. The comparison with Groups 1-4 will ascertain whether "more is better" in the realm of passive physical therapy, or if the redundancy or varying mechanisms might dilute or even confound individual therapeutic contributions. Philosophically, this group reflects a common clinical practice of employing multiple passive agents, driven by the intuition that a multifaceted attack on symptoms might yield superior results. The inquiry here is whether this intuition is supported by empirical evidence, particularly concerning resource allocation and patient exposure.

III. The Integrative and Empowering Approach: Passive Modalities + Active Kinesiotherapy (Group 6)

Group 6 stands as the methodological and philosophical cornerstone of this investigation, embodying a holistic, biopsychosocial approach that transcends mere symptomatic

management. It integrates the benefits of passive modalities with the transformative power of active, individualized kinesiotherapy and patient education.

- **Group 6 (Integrated Passive + Kinesiotherapy):** This protocol hypothesizes that while passive modalities may address acute symptoms and prepare tissues, the enduring resolution of CNLPS hinges upon active patient engagement, functional restoration, and self-efficacy. The kinesiotherapy component, encompassing core stabilization, stretching, mobilization, and progressive loading, directly addresses the underlying biomechanical dysfunctions and deconditioning often associated with chronic pain. Crucially, the embedded patient education fosters long-term self-management, ergonomic awareness, and recurrence prevention, shifting the locus of control towards the patient. The comparative analysis of Group 6 against all purely passive groups (Groups 1-5) will critically evaluate the philosophical proposition that active participation, guided movement, and empowered self-care are indispensable for sustainable therapeutic outcomes in CNLPS. This group posits that true rehabilitation extends beyond transient relief to encompass genuine functional adaptation and resilience.

IV. The Definitional Baseline: The Control Group (Group 7)

The inclusion of Group 7 serves a distinct and vital methodological function, providing the indispensable normative baseline against which the clinical significance of all interventions can be objectively measured.

- **Group 7 (Control Group - No CNLPS):** This group comprises individuals free from the diagnosis of CNLPS. Their data—encompassing functional status, pain perception, and quality of life metrics—establishes a crucial reference point, delineating the "normal" or healthy state. The comparison of Groups 1-6 with Group 7 allows for a robust quantification of the initial deficit presented by CNLPS patients and, more importantly, the extent to which each therapeutic protocol can restore individuals to a state approaching normative function and well-being.

Philosophically, this group underlines the fundamental objective of rehabilitation: to bridge the gap between a pathological state and a state of health, or at least optimal functional capacity. Without this reference, the magnitude and clinical relevance of therapeutic gains within the intervention groups would remain contextually ambiguous.

V. Comparative Trajectories and Expected Outcomes

The comparative analysis across these seven distinct groups will offer profound insights into the varied trajectories of recovery and the differential impact of therapeutic philosophies. It is anticipated that purely passive modalities (Groups 1-4) may yield symptomatic relief, particularly in the short term, but perhaps demonstrate less profound or durable improvements in functional ability. The combined passive approach (Group 5) may show incrementally superior symptomatic management due to broader physiological effects. However, the central hypothesis posits that the integrated active and passive model (Group 6), by fostering intrinsic strength, functional independence, and self-management, will ultimately demonstrate the most robust and sustainable improvements across all outcome measures, particularly those related to long-term disability and quality of life. The constant reference to the healthy control group (Group 7) will rigorously anchor these observations, preventing overestimation or underestimation of therapeutic efficacy.

This comprehensive comparative framework is not merely an exercise in statistical differentiation; it is a critical philosophical inquiry into the very nature of healing and rehabilitation in chronic pain. By meticulously dissecting and comparing these diverse therapeutic pathways, this research aims to contribute significantly to the evidence-based discourse, offering clinicians, researchers, and patients a clearer understanding of the optimal strategies for navigating the complexities of CNLPS.

Statistical and Clinical Relevance

- Differences between the groups were highly statistically significant ($p < 0.01$), confirming that the observed effects were not random but the result of differing therapeutic strategies.
- Combining passive physiotherapy with active, individualised kinesitherapy significantly enhances the effectiveness of rehabilitation compared with passive methods alone.
- These findings further support contemporary guidelines emphasising the importance of active patient participation and multimodal rehabilitation protocols for optimal recovery and long-term functional maintenance in LBP.

Discussion

10.1 Comparison with Existing Research and Scientific Evidence

The results of the present clinical study clearly demonstrate that a rehabilitation program combining passive physical modalities with active kinesitherapy is significantly more effective than the application of passive modalities alone in the treatment of lumbar pain syndrome (LPS). Patients who participated in structured exercise-based interventions alongside physical agents experienced greater reductions in pain intensity, improved lumbar mobility, and superior functional outcomes. These findings are consistent with current international research and contemporary clinical practice guidelines, which increasingly emphasize the importance of multimodal, patient-centered rehabilitation strategies—particularly in cases of chronic and recurrent low back pain.

The superiority of active, multidisciplinary approaches over isolated passive treatments has been extensively documented in the scientific literature. The European guidelines for the management of chronic low back pain, developed by Airaksinen and colleagues, provide a

comprehensive synthesis of available evidence and conclude that optimal outcomes are achieved through programs that combine active patient participation, therapeutic exercise, patient education, and interdisciplinary collaboration among healthcare professionals, including physiotherapists, physicians, and psychologists. These guidelines emphasize that although passive modalities may provide short-term symptom relief, their effectiveness diminishes over time. In contrast, active rehabilitation promotes patient autonomy, reduces disability, and contributes to sustained functional recovery.

Long-term benefits of active engagement in rehabilitation have also been demonstrated by Mannion et al., who followed patients for several years after completion of physiotherapy. Their findings showed that individuals who received structured education and actively participated in exercise programs experienced fewer recurrences of symptoms, longer-lasting pain reduction, and greater independence in daily activities. These results underscore the importance of continuous patient activation and motivation, as well as the integration of psychosocial components into rehabilitation programs—particularly for chronic conditions such as non-specific chronic low back pain (NCLBP).

Similarly, Koes and colleagues emphasized that multimodal rehabilitation approaches, which combine physical agents with various forms of exercise therapy, exert therapeutic effects on multiple levels, including biomechanical, neurological, and psychological mechanisms. Such interventions not only accelerate functional recovery but also promote neuroplastic changes and improvements in overall quality of life. Importantly, these approaches reduce the risk of pain chronification and recurrent healthcare utilization, outcomes that are particularly relevant in patients with chronic LPS.

Electromagnetic Field Therapy and Magnetotherapy

The role of electromagnetic field therapy in chronic low back pain has been investigated in several clinical studies. Miladinović et al. examined the effects of magnetotherapy and transcutaneous electrical nerve stimulation (TENS) in patients with chronic low back pain and reported significantly greater pain reduction in the magnetotherapy group. These

findings are in line with the present study, in which magnetotherapy demonstrated superior analgesic effects compared with TENS in patients with NCLBP.

Further support for these findings comes from Fortin, who applied electromagnetic field therapy to 38 patients with chronic lumbar pain and reported an average reduction of 30% in visual analogue scale (VAS) pain scores without any reported adverse effects. Comparable outcomes were observed in the present study, where patients in the magnetotherapy group demonstrated both pain reduction and improvements in lumbar mobility parameters.

Taradaj et al. conducted a prospective, randomized, single-blind, placebo-controlled clinical trial involving 106 patients with LPS associated with discopathy. Their results confirmed that magnetic field therapy significantly reduces pain and improves functional capacity compared with placebo. Although the present study did not include a placebo control group, the observed improvements in pain intensity and function support the therapeutic value of magnetotherapy as part of a comprehensive rehabilitation program.

Laser Therapy in Lumbar Pain Syndrome

Laser therapy, particularly low-level laser therapy (LLLT), has long been used in the treatment of chronic low back pain due to its analgesic and anti-inflammatory properties. More recently, high-intensity laser therapy (HILT) has emerged as a non-invasive and safe modality capable of penetrating deeper tissues. Clinical evidence supports its effectiveness in the management of various musculoskeletal conditions, including shoulder disorders, degenerative knee disease, chronic ankle pain, and spinal pain syndromes. The therapeutic effects of HILT are attributed to its anti-inflammatory, antiedematous, and analgesic mechanisms.

Zdrowska reported that both low-energy laser therapy and pulsed magnetic fields were effective in reducing pain in patients with lumbar disorders. While laser therapy produced greater analgesic effects, magnetic field therapy was associated with more pronounced improvements in lumbar mobility. These observations are partially reflected in the present

study, where laser therapy resulted in meaningful pain reduction, while magnetotherapy demonstrated notable effects on functional mobility.

Abdelbasset compared HILT with pulsed electromagnetic field therapy in patients with chronic non-specific low back pain and found that HILT produced significantly greater improvements in disability (measured by the Oswestry Disability Index), lumbar flexion range of motion, and pain intensity. Although the present study did not include combined or placebo-controlled laser protocols, the analgesic benefits observed in the laser therapy group are consistent with Abdelbasset's findings.

Ozkaraoglu et al. further demonstrated that HILT was more effective than TENS in reducing low back pain, suggesting that HILT may represent a valid alternative to traditional electrotherapy modalities. While a TENS group was not included in the present research, patients receiving laser therapy exhibited marked reductions in pain and improvements in lumbar mobility.

Gocevska compared HILT with therapeutic ultrasound and reported superior analgesic and functional outcomes in the HILT group, with benefits persisting for at least three months. In contrast, the present study found that ultrasound therapy produced significantly greater pain reduction and mobility improvement than laser therapy. These differences may be attributable to variations in treatment protocols, dosage parameters, patient characteristics, and outcome measures. Nevertheless, both studies reinforce the principle that passive modalities alone are insufficient and that exercise therapy must remain a central component of LPS management. This conclusion is strongly supported by the present findings, in which the combination of kinesitherapy and physical modalities resulted in a 52% reduction in pain, compared with a 25% reduction achieved by passive modalities alone.

Alayat et al. demonstrated that combining HILT with exercise therapy led to significantly superior outcomes compared with HILT alone or placebo laser combined with exercise. Although laser therapy was not combined with exercise in the present study, the observed analgesic effects support the role of HILT as a valuable adjunct within a broader, active rehabilitation framework.

Therapeutic Ultrasound

Therapeutic ultrasound remains one of the most widely used electro-physical modalities in physiotherapy practice. However, high-quality evidence supporting its effectiveness in chronic low back pain is limited, and reported clinical improvements are often modest and not always clinically meaningful. Despite these limitations, ultrasound's mechanical effects—such as tissue vibration, enhanced circulation, and analgesia—have been shown to contribute to functional improvement in some patients.

Ebadi et al. reported that both therapeutic and placebo ultrasound, when combined with partially supervised exercise programs, resulted in pain reduction over time. Although placebo ultrasound was not examined in the present study, patients receiving ultrasound therapy demonstrated notable improvements in both pain intensity and lumbar mobility.

Licciardone et al. found no statistically significant differences between therapeutic ultrasound and sham treatment over ten sessions, whereas Durmuş et al. reported significant pain reduction in groups receiving exercises combined with either electrostimulation or ultrasound, compared with control groups. The present results partially align with these findings, as ultrasound therapy produced measurable benefits, while the greatest improvements were observed in the group receiving combined physical modalities and kinesitherapy.

Traditional Chinese Medicine Approaches

Several studies have reported that acupuncture and related traditional Chinese medicine (TCM) interventions may improve circulation, reduce nerve compression, decrease inflammation, and alleviate pain. However, the availability and integration of TCM into conventional healthcare systems vary widely. In Croatia, TCM modalities are not routinely available within public healthcare and remain limited in private practice, which restricts their broader clinical applicability in this context.

Limitations of the Present Research

Despite its strengths, this study has several limitations. The treatment duration was relatively short, consisting of a single therapeutic cycle of ten sessions. The study population did not include older adults over the age of 65, limiting generalizability to elderly patients. Long-term follow-up was not conducted, preventing assessment of sustained outcomes and recurrence rates. Pain assessment remains inherently subjective, as objective biomarkers of pain are currently unavailable. Additionally, a larger sample size and extended monitoring period would enhance external validity. Future research should compare acute and chronic LBP populations, evaluate individual modalities in larger cohorts, and incorporate placebo-controlled designs where feasible. Although placebo ultrasound and mixed-modality placebo groups were not included, the results still demonstrate that therapeutic ultrasound positively influences pain reduction and lumbar mobility.

Broader Implications and Public Health Significance

The findings of this study have important implications not only for daily clinical practice but also for public health planning. Demonstrating the superior effectiveness of combined rehabilitation programs highlights the need for healthcare systems to ensure access to individualized, active therapy, patient education, and continuous monitoring. The role of multidisciplinary teams emerges as a critical determinant of successful outcomes, supporting investment in workforce training and professional development.

In conclusion, the present study reinforces existing clinical guidelines and scientific evidence, emphasizing that the future of lumbar pain rehabilitation lies in personalized, active, and interdisciplinary approaches rather than outdated models based solely on passive treatment modalities.

10.2 Clinical Implications for Rehabilitation Practice

The results of this clinical study have direct and meaningful implications for everyday rehabilitation practice and allow for the formulation of clear, evidence-based recommendations for the management of patients with lumbar pain syndrome. These implications are derived from the study's findings and supported by contemporary international literature and clinical practice guidelines.

Since 2001, structured clinical practice guidelines for the treatment of non-specific LPS have been increasingly implemented within primary healthcare settings. Oliveira et al. conducted a comprehensive review of clinical guidelines published between 2008 and 2017, drawing from major electronic databases including MEDLINE via OVID, PEDro, the National Guideline Clearinghouse, and the National Institute for Health and Care Excellence (NICE). Guidelines addressing diagnosis and treatment of non-specific low back pain and involving multidisciplinary healthcare professionals—primarily physiotherapists, kinesiotherapists, and occupational therapists—were included.

An analysis of the Cochrane Central Register of Controlled Trials (CENTRAL) revealed that the number of randomized controlled trials investigating LPS nearly doubled after 2010, reflecting growing scientific interest in evidence-based management. Following the removal of duplicates, 1,611 records were identified, and 15 clinical practice guidelines from countries across multiple continents were ultimately included.

Most guidelines recommended maintaining normal activity levels and avoiding bed rest, particularly for patients with acute LPS. A substantial proportion emphasized the importance of reassuring patients that LPS is not a serious condition and that prognosis is generally favorable. Pharmacological management, primarily with NSAIDs, was widely recommended, with careful consideration of potential adverse effects. Weak opioids were suggested for short-term use when necessary, while antidepressants were frequently recommended for chronic LPS. Recommendations for muscle relaxants and paracetamol varied, reflecting ongoing debate regarding their effectiveness.

A striking finding was that 90% of guidelines endorsed multidisciplinary rehabilitation for chronic LPS, underscoring the necessity of coordinated, team-based care. Importantly, all reviewed guidelines included recommendations for exercise therapy, with the majority supporting its use in chronic LPS. Although the specific types of exercise programs varied, the consistent message across guidelines was that physical activity and movement-based interventions are essential components of effective rehabilitation.

Kinesitherapy as the Foundation of Rehabilitation

The results of the present study strongly support the role of kinesitherapy as the cornerstone of rehabilitation in subacute and chronic lumbar pain. Active movement therapy enhances neuromuscular control, strengthens deep stabilizing musculature, improves proprioception, and restores functional movement patterns. Beyond physical benefits, regular exercise contributes to reductions in psychological stress, anxiety, and depressive symptoms—factors that are frequently present in chronic pain populations.

Accordingly, individualized, progressive, and professionally supervised exercise programs should be integrated into standard rehabilitation protocols for all patients with prolonged lumbar pain.

Limitations and Appropriate Use of Passive Modalities

Passive modalities such as electrotherapy, ultrasound, and magnetotherapy retain value, particularly during the acute phase when pain dominates clinical presentation. However, exclusive or prolonged reliance on passive interventions results in inferior long-term outcomes. As pain levels decrease and functional capacity improves, active interventions must be introduced promptly. While combined passive and active approaches may shorten the acute phase and facilitate earlier return to normal activities, sustained recovery depends on the patient's active participation in rehabilitation.

Patient Education as a Core Therapeutic Element

Patient education is a fundamental component of successful rehabilitation. Well-informed patients demonstrate greater adherence, higher motivation, and improved functional outcomes. Education should address the nature of LPS, proper exercise performance, ergonomic principles, strategies for recurrence prevention, and the role of psychological well-being. Educational materials and individualized guidance should be consistently available throughout the rehabilitation process.

Individualization Based on Functional Assessment

The present findings confirm that rehabilitation programs tailored to functional status—assessed using validated tools such as the Roland–Morris Disability Questionnaire (RMDQ), Oswestry Disability Index (ODI), and VAS—yield superior outcomes compared with standardized, diagnosis-driven protocols. Rehabilitation plans should be continuously adjusted based on patient progress, motivation, and comorbidities, with functional reassessment conducted throughout treatment.

Broader Clinical Perspective

Collectively, these clinical implications highlight the necessity of interdisciplinary collaboration, ongoing professional education, and investment in personalized rehabilitation services. The results suggest that both patients and healthcare systems will derive long-term benefit when active kinesitherapy is established as the standard of care across all stages of recovery from lumbar pain syndrome.

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Conclusion

11.1 Summary of Findings and Recommendations

Following the completion of the study, all participants demonstrated a higher level of functional ability. The most effective physiotherapy method was observed in Group 6, which received a combination of all physiotherapeutic procedures together with kinesitherapy of the lumbosacral spine.

Conclusions Based on Statistical Data

1. The study shows that the level of functional ability in patients is significantly higher after therapy. Improvements in mobility, independence and overall functional status were evident in all patients across all treatment groups.
2. When comparing Groups 1, 2, 5 and 7 with Group 3, it may be concluded that there is a statistically significant difference in the sagittal mobility index according to the post hoc Scheffé test.
3. According to the post hoc Scheffé test for anteflexion, the greatest improvement was observed in Group 4, which was treated with magnetotherapy.
4. For right and left lateral flexion, there is no statistically significant difference regardless of the type of therapy applied.
5. All tests used to assess lumbar spine range of motion—sagittal mobility index, Lasègue test, Thomayer measure—showed improvement in all groups following therapy.

This clinical study, conducted on a sample of 210 patients with clearly diagnosed lumbar pain syndrome (LPS), represents one of the most comprehensive research efforts in the field to date

within the domestic and regional context. The collected data confirm long-standing assumptions regarding the importance of an integrated, multidisciplinary approach to rehabilitation and provide detailed insight into optimal therapeutic strategies applicable in everyday clinical practice.

The key findings are as follows:

- **Effectiveness of physiotherapeutic modalities:** All included passive methods (magnetotherapy, electrotherapy, ultrasound and low-frequency laser therapy) demonstrated positive effects in reducing pain and improving functional status in patients with LPS, particularly during the acute and subacute phases of the condition. These results are consistent with previous studies emphasising the value of such methods in the early stages of recovery, where pain and swelling control are crucial for enabling further progress.
- **Advantages of integrating active kinesitherapy:** The most important finding of this study is the clearly demonstrated superiority of combined therapeutic protocols incorporating targeted kinesitherapy—particularly exercises focused on trunk stabilisation, proprioception and flexibility. Patients in the active intervention group achieved greater and more sustained symptom reduction, accompanied by substantial improvements in daily functioning. Kinesitherapy not only accelerated recovery but also helped prevent recurrence of symptoms and improved overall quality of life.
- **Statistical relevance of the outcomes:** Differences in therapeutic outcomes between the passive-only and combined (active) treatment groups were highly statistically significant ($p < 0.01$). This confirms that the inclusion of kinesitherapy in standard rehabilitation should become an obligatory element of treatment, as it provides clinically meaningful and measurable benefits for patients.
- **Individualised, function-oriented approach:** The study demonstrates that the best outcomes are achieved by patients whose therapy is tailored to their individual functional capabilities, motivation and goals, rather than relying solely on radiological findings. Dynamic functional assessment and continuous adjustment of therapy are crucial for optimal progress and for maintaining results after completion of the rehabilitation programme.
- **Importance of patient education and motivation:** Educating patients and ensuring their active participation throughout the entire treatment process significantly enhances therapeutic effectiveness, strengthens the sense of control and confidence in the rehabilitation process, and contributes to long-term maintenance of functional improvements.

Recommendations for Clinical Practice

1. Implementation of structured and supervised kinesitherapy as a mandatory component of rehabilitation, especially for patients with chronic or recurrent pain, but also in earlier phases as soon as pain becomes manageable. These exercises should be individualised, progressive and continuously supervised by qualified professionals.
2. Systematic education and continuous motivation of patients: Patients should receive clear and practical instruction on the importance of regular exercise, correct ergonomics and strategies for preventing recurrence of pain. Brochures, educational videos and workshops are recommended as supportive tools for daily self-management.
3. Multidisciplinary collaboration as standard practice: Optimal results are achieved when rehabilitation involves cooperation between physicians, physiotherapists, kinesiologists and, when needed, psychologists or occupational therapists. Such an approach allows for a holistic assessment of the patient's needs and ensures optimal adjustment of interventions.
4. Encouraging long-term research and follow-up: Further longitudinal studies are recommended to evaluate the long-term effectiveness of combined therapies, their role in reducing recurrence, maintaining functional independence and improving overall quality of life in patients with LBS.

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I. Figure Captions

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Figure 25. – 33. *Polyclinic Drinković Office 2 for physical medicine and rehabilitation.* Polyclinic Drinković (Photograph taken with Apple iPhone 15 Pro Max, 2024).

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13

Appendix

13.1 Sample Kinesiotherapy Exercises

Kinesiotherapy for Lumbar Pain Syndrome

Kinesiotherapy for lumbar pain syndrome constitutes a core component of conservative management for individuals with low back pain. It encompasses a structured and evidence-based selection of therapeutic exercises tailored to the patient's functional limitations and clinical presentation. The primary aim of kinesiotherapy is to restore optimal movement patterns while minimizing mechanical stress on the lumbar spine. Exercise interventions target both deep trunk stabilizing musculature and global movement muscles to promote balanced spinal support. Emphasis is placed on improving muscular strength, endurance, flexibility, coordination, and neuromuscular control. Proper activation of the deep stabilizing system contributes to enhanced segmental stability and postural control. Progressive loading strategies are employed to facilitate tissue adaptation and functional recovery. Exercise dosage is adjusted according to symptom response and individual tolerance. Correct technique is essential to prevent compensatory movement patterns and symptom exacerbation. Continuous clinical supervision ensures safety and promotes adherence to therapeutic goals. Exercises are commonly progressed from low-load, static positions to dynamic, functional tasks. Individualization of exercise programs is critical to address variability in pain presentation and physical capacity. Kinesiotherapy also supports patient education and active self-management strategies. Integration of therapeutic exercise into daily activities enhances long-term functional outcomes. Consistent participation in kinesiotherapy has been shown to reduce pain-related disability. Overall, this approach plays a pivotal role in improving quality of life and preventing recurrence of lumbar pain.

13.1.1. Selective Activation of the Transversus Abdominis for Lumbar Segmental Stabilization

Selective activation of the transversus abdominis is a cornerstone of contemporary lumbar spine rehabilitation. This muscle forms the deepest layer of the abdominal wall and functions as a primary stabilizer of the lumbar segments. It contributes to spinal stability by increasing intra-abdominal pressure and tensioning the thoracolumbar fascia. Research has demonstrated delayed or impaired activation of the transversus abdominis in individuals with chronic low back pain. Abdominal hollowing techniques are used to retrain precise neuromuscular control of this muscle. Proper execution requires minimal activation of the rectus abdominis and oblique muscles. Maintaining normal breathing during contraction is essential to avoid compensatory patterns. Early training is performed in supported positions to reduce spinal load. Visual and tactile feedback may enhance motor learning. Gradual increases in hold duration improve muscular endurance. Integration with pelvic floor activation further enhances trunk stabilization. Progression to upright positions increases functional relevance. Consistent practice improves postural control during daily activities. This exercise reduces excessive lumbar motion during limb movement. It serves as a foundation for more complex stabilization exercises. Long-term training contributes to reduced recurrence of lumbar pain.

13.1.2. Quadruped Contralateral Arm–Leg Extension (Bird Dog) for Neuromuscular Control and Trunk Stability

The quadruped contralateral arm–leg extension exercise is widely used to improve dynamic trunk stability. It challenges the neuromuscular system to maintain spinal alignment during limb movement. The exercise activates deep spinal stabilizers, including the multifidus and transversus abdominis. Gluteal and scapular stabilizing muscles also play a significant role. Maintaining a neutral lumbar spine is a primary objective. Pelvic rotation or trunk shifting indicates insufficient control. Slow, deliberate movement enhances proprioceptive feedback. Holding the extended position increases isometric endurance demands. Alternating sides promotes symmetrical muscle activation. This exercise improves coordination between the upper and lower extremities. It closely resembles functional load-transfer tasks such as walking. Progressions increase resistance to rotational forces. External resistance further challenges stability. The exercise can be adapted for different rehabilitation stages. It is suitable for both clinical and home programs. Regular performance enhances overall spinal control.

13.1.3. Cat–Camel Exercise for Dynamic Lumbar Spine Mobility and Segmental Flexibility

The cat–camel exercise is a controlled spinal mobility exercise performed in a quadruped position. It facilitates alternating flexion and extension of the spine. This movement promotes segmental motion across the lumbar and thoracic regions. Cyclic spinal motion enhances intervertebral disc nutrition. The exercise reduces muscular stiffness and joint restriction. It is often used to decrease pain-related guarding. Slow execution improves awareness of spinal positioning. Breathing patterns are coordinated with movement to promote relaxation. Excessive end-range loading should be avoided. The exercise is appropriate for early rehabilitation phases. It serves as an effective warm-up activity. Cat–camel movements improve flexibility without external load. They encourage symmetrical spinal motion. Reduced range may be used for sensitive patients. The exercise supports recovery after prolonged static postures. Regular practice improves overall spinal comfort.

13.1.4. Side Plank Exercise for Lateral Trunk Stabilization and Lumbo-Pelvic Control

The side plank exercise is designed to strengthen the lateral stabilizers of the trunk. It primarily targets the internal and external oblique muscles. The quadratus lumborum plays a critical role during this exercise. These muscles contribute to frontal-plane spinal stability. Proper body alignment is essential for effective activation. The pelvis should remain elevated and level throughout the hold. The exercise challenges isometric endurance rather than maximal force. Short hold durations are appropriate for beginners. Progressive increases enhance muscular endurance. Modified versions reduce load and increase safety. Advanced variations significantly increase stabilization demands. The side plank improves unilateral trunk control. It has functional relevance for gait and carrying tasks. Poor technique may increase lumbar strain. Continuous supervision is recommended during early practice. This exercise supports balanced lumbo-pelvic stability.

13.1.5. Supine Glute Bridge Exercise for Posterior Chain Strengthening and Lumbar Load Reduction

The glute bridge exercise is a fundamental posterior chain strengthening activity. It emphasizes activation of the gluteus maximus. Hamstrings and deep abdominal muscles assist during execution. Proper hip extension reduces reliance on lumbar extensors. Excessive lumbar arching should be avoided. Controlled movement enhances neuromuscular coordination. Holding the top position increases isometric strength. The exercise improves pelvic stability during functional tasks. Single-leg variations introduce unilateral loading. Resistance bands increase hip abductor activation. The exercise promotes balanced force distribution across the lumbopelvic region. It is commonly prescribed in rehabilitation programs. Proper foot placement improves activation patterns. The glute bridge supports lifting and walking mechanics. It reduces lumbar strain during daily activities. Progressive loading enhances long-term strength gains.

13.1.6. Dead Bug Exercise for Anterior Core Stabilization and Motor Control

The dead bug exercise is a supine stabilization exercise emphasizing controlled limb movement. It challenges the ability to maintain a stable trunk. The lumbar spine should remain neutral throughout the exercise. This promotes effective anterior core activation. The exercise targets the transversus abdominis and rectus abdominis. Coordination between upper and lower limbs is required. Slow execution minimizes compensatory movement. Maintaining spinal contact with the surface provides feedback. The exercise has low compressive spinal load. It is suitable for early rehabilitation stages. Progressions increase lever arm length. Alternating patterns improve neuromuscular control. The dead bug enhances trunk endurance. It supports functional activities such as lifting. The exercise improves movement efficiency. It is widely used in motor control–based therapy.

13.1.7. Wall-Supported Static Squat (Wall Sit) for Lower Extremity and Trunk Endurance

The wall-supported static squat is an isometric strengthening exercise. It primarily targets the quadriceps muscles. Gluteal and trunk muscles contribute to postural stability. The wall provides external support for spinal alignment. This reduces dynamic spinal loading. Proper knee alignment is essential. Hip and knee angles influence muscular demand. Breathing should remain controlled throughout the hold. The exercise improves muscular endurance. Hold duration can be progressively increased. It is suitable for individuals with movement limitations. The wall sit supports functional tolerance to standing. It enhances lower limb strength without motion. The exercise is often used in later rehabilitation stages. Fatigue should be monitored closely. Regular practice improves postural endurance.

13.1.8. Prone Trunk and Hip Extension (Superman Exercise) for Spinal Extensor Strengthening

The prone trunk and hip extension exercise strengthens spinal extensors. It targets the erector spinae muscles. Gluteal activation assists in hip extension. Proper technique limits excessive lumbar compression. The exercise should be performed with controlled lifting. Short hold durations reduce overload risk. Alternating limb lifts provide a safer modification. The exercise improves posterior chain endurance. It supports upright posture maintenance. Individuals with acute pain require caution. Excessive range of motion should be avoided. The exercise is typically prescribed in advanced phases. Supervision improves safety and effectiveness. Gradual progression increases tolerance. The exercise enhances spinal extension strength. It contributes to functional back support.

13.1.9. Supine Posterior Pelvic Tilt for Lumbo-Pelvic Alignment and Core Activation

The posterior pelvic tilt exercise promotes awareness of pelvic positioning. It emphasizes activation of the lower abdominal muscles. This movement reduces excessive lumbar lordosis. Controlled tilting improves lumbo-pelvic coordination. The exercise is low-load and well tolerated. It is commonly used in early rehabilitation. Breathing should remain relaxed and controlled. Repetition enhances motor learning. The exercise improves postural awareness. It may reduce lumbar discomfort. Pelvic control supports functional movement patterns. The exercise can be performed throughout the day. It serves as a foundation for stabilization training. Proper instruction ensures correct activation. Progression involves integrating limb movement. This exercise supports long-term spinal health.

13.1.10. Dynamic Lunge Variations for Functional Lumbo-Pelvic Stability and Balance Training

Dynamic lunges are functional lower extremity exercises. They challenge strength, balance, and coordination simultaneously. Proper technique emphasizes controlled joint motion. Trunk alignment must be maintained throughout. Lunges activate gluteal and core muscles. Forward lunges emphasize sagittal-plane control. Lateral lunges challenge frontal-plane stability. The exercise improves load transfer through the pelvis. Balance demands enhance proprioceptive input. Lunges replicate daily movement tasks. They are typically introduced in advanced rehabilitation. External resistance increases training demand. Poor technique may increase lumbar strain. Supervision is recommended during early practice. Lunges improve functional capacity. They support return to work and sport activities.

13.2. Questionnaire Templates

Questionnaire Forms

Introduction

Assessment of functional status and the degree of disability is a key component in evaluating and monitoring patients with lumbar pain syndrome. Standardised questionnaires allow objective documentation of subjective symptoms and enable the monitoring of progress throughout therapy and rehabilitation. This appendix includes the two most commonly used scales, each presented in Croatian and English, along with detailed instructions for their use and interpretation.

13.2.1. Roland–Morris Disability Questionnaire (RMDQ)

Instructions

Purpose:

The questionnaire is intended for patients with low back pain, to assess how the pain affects their everyday activities. It is ideally used before the start and after completion of a therapeutic cycle, in order to quantify changes in functional ability.

Instructions for completion:

- The patient should read each of the 24 statements and tick those that reflect their current condition on that day.
- Each ticked statement is worth one point.
- Scores are summed (range 0–24); a higher score indicates greater disability.

Examples of statements (in Croatian):

- “Because of my back, I avoid lifting heavy objects.”
- “Because of my back, I find it difficult to put on or take off my shoes.”

Clinical notes:

- The RMDQ is highly sensitive for detecting small changes and is therefore recommended for monitoring the effects of physiotherapy, medication or surgical interventions.

13.2.2. Original RM Questionnaire in Croatian

Croatian version of the Roland-Morris disability questionnaire produced by MAPI in 2004.

A summary of the translation process is at the end of the questionnaire.

Kada Vas bole leđa, možda Vam je teško činiti neke stvari koje inače radite.

Ovaj popis sadrži neke rečenice koje ljudi koriste da bi opisali svoje stanje kada ih bole leđa. Kad ih pročitate, možda primijetite da se neke od njih ističu jer opisuju Vaše *današnje* stanje. Dok čitate popis, razmišljajte o sebi *danas*. Kad nađete na rečenicu koja opisuje Vaše stanje *danas*, prekrižite kvadratić uz nju. Ako rečenica ne opisuje Vaše stanje, kvadratić ostavite neoznačen i prijedite na sljedeću rečenicu. **Ne zaboravite, označite rečenice samo ako ste sigurni da opisuju Vaše *današnje* stanje.**

1. Zbog boli u leđima najveći dio dana ostajem kod kuće.
2. Često mijenjam položaj nastojeći naći udoban položaj za leđa.
3. Zbog boli u leđima hodam sporije nego inače.
4. Zbog boli u leđima ne obavljam niti jedan od poslova koje obično obavljam u kući.
5. Zbog boli u leđima koristim se rukohvatom pri uspinjanju stubama.
6. Zbog boli u leđima češće nego inače legnem da bih se odmorio / odmorila.
7. Zbog boli u leđima moram se za nešto pridržavati da bih ustao / ustala iz naslonjača.
8. Zbog boli u leđima molim druge ljude da obavljaju stvari umjesto mene.
9. Zbog boli u leđima oblačim se sporije nego inače.

10. Zbog boli u leđima stojim samo nakratko.
11. Zbog boli u leđima nastojim se ne saginjati i ne klečati.
12. Zbog boli u leđima teško mi je ustati sa stolice.
13. Leđa me bole većinu vremena.
14. Zbog boli u leđima teško mi je okrenuti se u krevetu.
15. Zbog boli u leđima nemam dobar apetit.
16. Zbog boli u leđima teško mi je obući čarape.
17. Zbog boli u leđima hodam samo na kratke udaljenosti.
18. Zbog boli u leđima spavam manje nego inače.
19. Zbog boli u leđima oblačim se uz nečiju pomoć.
20. Zbog boli u leđima najveći dio dana provodim sjedeći.
21. Zbog boli u leđima izbjegavam teške poslove u kući.
22. Zbog boli u leđima sam prema ljudima razdražljiviji / razdražljivija i lošije raspoložen / raspoložena nego inače.
23. Zbog boli u leđima stubama se uspinjem sporije nego inače.
24. Zbog boli u leđima najveći dio dana ostajem u krevetu.

13.2.3. Original Roland-Morris Disability Questionnaire in English

When your back hurts, you may find it difficult to do some of the things you normally do.

This list contains sentences that people have used to describe themselves when they have back pain. When you read them, you may find that some stand out because they describe you *today*.

As you read the list, think of yourself *today*. When you read a sentence that describes you today, put a tick against it. If the sentence does not describe you, then leave the space blank and go on to the next one. Remember, only tick the sentence if you are sure it describes you today.

1. I stay at home most of the time because of my back.
2. I change position frequently to try and get my back comfortable.
3. I walk more slowly than usual because of my back.
4. Because of my back I am not doing any of the jobs that I usually do around the house.
5. Because of my back, I use a handrail to get upstairs.
6. Because of my back, I lie down to rest more often.

7. Because of my back, I have to hold on to something to get out of an easy chair.
8. Because of my back, I try to get other people to do things for me.
9. I get dressed more slowly than usual because of my back.
10. I only stand for short periods of time because of my back.
11. Because of my back, I try not to bend or kneel down.
12. I find it difficult to get out of a chair because of my back.
13. My back is painful almost all the time.
14. I find it difficult to turn over in bed because of my back.
15. My appetite is not very good because of my back pain.
16. I have trouble putting on my socks (or stockings) because of the pain in my back.
17. I only walk short distances because of my back.
18. I sleep less well because of my back.
19. Because of my back pain, I get dressed with help from someone else.

20. I sit down for most of the day because of my back.
21. I avoid heavy jobs around the house because of my back.
22. Because of my back pain, I am more irritable and bad tempered with people than usual.
23. Because of my back, I go upstairs more slowly than usual.
24. I stay in bed most of the time because of my back.

Note to users:

This questionnaire is taken from: Roland MO, Morris RW. A study of the natural history of back pain. Part 1: Development of a reliable and sensitive measure of disability in low back pain. Spine 1983; 8: 141-144

The score of the RDQ is the total number of items checked – i.e. from a minimum of 0 to a maximum of 24.

It is acceptable to add boxes to indicate where patients should tick each item.

The questionnaire may be adapted for use on-line or by telephone.

13.2.4. Original ODI Questionnaire in Croatian

Oswestry upitnik za procjenu invalidnosti uzrokovanu boli

UPITNIK ONESPOSOBLJENOSTI

UPUTE: Odgovorite na pitanja navedena ispod odabirući odgovor koji najbolje opisuje Vašu „tipičnu“ bol i/ili ograničenja posljednjih tjedan dana. Možete odabrati samo **JEDNU** tvrdnju iz svakog područja. Ako se dvoumite između dvije tvrdnje, odaberite tvrdnju s većim brojem bodova. **Ispunite upitnik!**

Područje 1. Intenzitet boli

- Mogu tolerirati bol bez analgetika. [0 bodova]
- Bol je jaka, ali liječim je bez analgetika. [1 bod]
- Analgetici u potpunosti otklanjaju bol. [2 boda]
- Analgetici daju umjereno smanjenje boli. [3 boda]
- Analgetici vrlo malo olakšavaju bol. [4 boda]
- Analgetici nemaju utjecaja na moju bol i ne koristim ih. [5 bodova]

Područje 2. Osobna njega

- Mogu se brinuti o sebi bez da mi to uzrokuje dodatnu bol. [0 bodova]
- Mogu se brinuti o sebi, ali mi to uzrokuje dodatnu bol. [1 bod]
- Bolno mi je skrbiti se o sebi, spor sam i pažljiv. [2 boda]
- Trebam nekoga za pomoć, ali većinu skrbi o sebi radim sam. [3 boda]
- Trebam tuđu pomoć svaki dan. [4 boda]
- Ne mogu oprati odjeću bez poteškoća, prikovan sam za krevet. [5 bodova]

Područje 3. Podizanje

- Mogu podići teške predmete bez boli. [0 bodova]
- Mogu podići teške predmete, ali uz bol. [1 bod]

Bol me sprječava u dizanju teških predmeta sa poda, ali ih mogu pomaknuti ako su prikladno položeni, npr. na stolu. [2 boda]

Bol me sprečava da dižem teške, ali mogu dizati lakše do srednje teške predmete, ako su prikladno položeni. [3 boda]

Mogu podići samo vrlo lagane predmete. [4 boda]

Ništa ne mogu podići ili prenijeti. [5 bodova]

Područje 4. Pješачenje

Bol me ne sprečava u pješaćenju na bilo koju udaljenost. [0 bodova]

Bol me sprečava u pješaćenju dužem od 1 km. [1 bod]

Bol me sprečava u pješaćenju dužem od 500 metara. [2 boda]

Bol me sprečava u pješaćenju dužem od 250 metara. [3 boda]

Mogu pješaćiti samo uz pomoć štapa ili štaka. [4 boda]

Prikovan sam za krevet većinu vremena i na toalet idem pužući. [5 bodova]

Područje 5. Sjedenje („Omiljena stolica“ uključuje fotelju s pokretnim naslonom)

Mogu sjediti na bilo kojoj stolici koliko dugo želim. [0 bodova]

Mogu sjediti samo u mojoj omiljenoj stolici koliko dugo želim. [1 bod]

Bol me sprečava da sjedim dulje od jednog sata. [2 boda]

Bol me sprečava da sjedim dulje od pola sata. [3 boda]

Bol me sprečava da sjedim dulje od deset minuta. [4 boda]

Bol me sprečava da sjedim. [5 bodova]

Područje 6: Stajanje (Zapamtite, stajanje nije hodanje)

Mogu stajati koliko želim bez boli. [0 bodova]

Mogu stajati koliko želim, ali mi to uzrokuje bol. [1 bod]

Bol me sprečava da stojim dulje od 1 sata. [2 boda]

Bol me sprečava da stojim dulje od 30 minuta. [3 boda]

Bol me sprečava da stojim dulje od 10 minuta. [4 boda]

Bol me sprečava da stojim. [5 bodova]

Područje 7: Spavanje

Bol me ne ometa u spavanju. [0 bodova]

Mogu zaspati bez uzimanja tableta. [1 bod]

Čak i kada uzmem tablete, spavam manje od 6 sati. [2 boda]

Čak i kada uzmem tablete, spavam manje od 4 sata. [3 boda]

Čak i kada uzmem tablete, spavam manje od 2 sata. [4 boda]

Bol me posve sprječava u spavanju. [5 bodova]

Područje 8: Seksualni život (bol= strah od uzroka boli)

Moj seksualni život je uredan i ne uzrokuje bol. [0 bodova]

Moj seksualni život je uredan, ali uz bol. [1 bod]

Moj seksualni život je skoro uredan, ali uz izrazitu bol. [2 boda]

Moj seksualni život je jako ograničen zbog boli. [3 boda]

Mog seksualnog života skoro nema zbog boli. [4 boda]

Bol me posve sprječava u seksualnom životu. [5 bodova]

Područje 9. Socijalni život

Moj socijalni život je normalan i ne uzrokuje mi bol. [0 bodova]

Moj socijalni život je normalan , ali povećava mi stupanj boli. [1 bod]

Bol nema značajan utjecaj na moj socijalni život, osim na energične aktivnosti, npr. ples. [2 boda]

Bol ograničava moj socijalni život i ne mogu ići van tako često. [3 boda]

Bol ograničava moj socijalni život na aktivnosti u kući. [4 boda]

Zbog boli nemam socijalnog života. [5 bodova]

Područje 10: Putovanje

Mogu putovati bilo gdje bez boli. [0 bodova]

Mogu putovati bilo gdje uz bolnost. [1 bod]

Bol je prisutna, ali mogu putovati dulje od 2 sata. [2 boda]

Bol me ograničava na putovanja kraća od 1 sata. [3 boda]

Bol me ograničava na kratka neophodna putovanja ispod 30 minuta. [4 boda]

Bol me sprječava u putovanju izuzev posjet liječniku ili bolnici. [5 bodova]

Očitavanje upitnika:

- Postotci od 0 do 20 % predstavljaju minimalnu invalidnost. Bolesnici s tim postotkom invalidnosti mogu se nositi s većinom dnevnih aktivnosti. Bolesnike treba podučiti o pravilnom sjedanju, ustajanju, dizanju tereta te nije potrebno posebno liječenje.
- Postotci od 21 do 40 % predstavljaju umjerenu invalidnost, a bolesnici u toj skupini osjećaju jače bolove pri sjedanju, ustajanju i dizanju tereta. Putovanja i društveni život su otežani te takvi bolesnici ponekad ne mogu obavljati svoj redoviti posao. Osobna njega, seksualne aktivnosti i spavanje nisu jako zahvaćeni, a liječenje takvih bolesnika može biti konzervativno.
- Bolesnici koji imaju postotak od 41 do 60 % imaju tešku invalidnost. Bol je glavni problem u tih bolesnika s ograničenim svakodnevnim aktivnostima. Ti bolesnici zahtijevaju detaljnu obradu.
- Bolesnici s postotkom od 61 do 80 % jesu invalidi i njihova bol u leđima utječe na sve vidove njihova života. U tih bolesnika potrebna je intervencija pri njihovom liječenju.
- Bolesnici s 81 do 100 % prikovani su za krevet ili takvi bolesnici preuveličavaju svoje simptome.

13.2.5. Original ODI Questionnaire in English

INSTRUCTIONS:

Answer the questions below by selecting the statement that best describes your “typical” pain and/or limitations over the past week. You may choose only ONE statement in each section. If you are uncertain between two statements, select the one with the higher score. Please complete the entire questionnaire.

Section 1: Pain Intensity

- I can tolerate the pain without using painkillers. [0 points]
- The pain is severe, but I manage without taking painkillers. [1 point]
- Painkillers completely relieve my pain. [2 points]
- Painkillers provide moderate relief of pain. [3 points]
- Painkillers provide very little relief. [4 points]
- Painkillers have no effect on my pain and I do not take them. [5 points]

Section 2: Personal Care

- I can look after myself normally without causing extra pain. [0 points]
- I can look after myself, but it causes extra pain. [1 point]
- Looking after myself is painful; I am slow and careful. [2 points]
- I need some help, but manage most of my personal care myself. [3 points]
- I need help every day. [4 points]

- I am unable to wash or dress without difficulty; I am confined to bed. [5 points]

Section 3: Lifting

- I can lift heavy objects without pain. [0 points]
- I can lift heavy objects, but it causes pain. [1 point]
- Pain prevents me lifting heavy objects from the floor, but I can manage if they are conveniently positioned, e.g. on a table. [2 points]
- Pain prevents me lifting heavy objects, but I can lift light to moderately heavy objects if they are conveniently positioned. [3 points]
- I can only lift very light objects. [4 points]
- I cannot lift or carry anything. [5 points]

Section 4: Walking

- Pain does not prevent me walking any distance. [0 points]
- Pain prevents me walking more than 1 km. [1 point]
- Pain prevents me walking more than 500 metres. [2 points]
- Pain prevents me walking more than 250 metres. [3 points]
- I can only walk using a stick or crutches. [4 points]
- I am confined to bed most of the time and crawl to the toilet. [5 points]

Section 5: Sitting

(“Favourite chair” includes a chair with a reclining back)

- I can sit on any chair for as long as I wish. [0 points]
- I can only sit in my favourite chair for as long as I wish. [1 point]
- Pain prevents me sitting for longer than one hour. [2 points]
- Pain prevents me sitting for longer than half an hour. [3 points]
- Pain prevents me sitting for longer than ten minutes. [4 points]
- Pain prevents me sitting at all. [5 points]

Section 6: Standing

(Remember – standing is not the same as walking)

- I can stand as long as I like without pain. [0 points]
- I can stand as long as I like, but it causes pain. [1 point]
- Pain prevents me standing for longer than one hour. [2 points]
- Pain prevents me standing for longer than 30 minutes. [3 points]
- Pain prevents me standing for longer than 10 minutes. [4 points]
- Pain prevents me standing at all. [5 points]

Section 7: Sleeping

- Pain does not interfere with my sleep. [0 points]
- I can sleep without taking tablets. [1 point]
- Even when taking tablets, I sleep less than 6 hours. [2 points]
- Even when taking tablets, I sleep less than 4 hours. [3 points]

- Even when taking tablets, I sleep less than 2 hours. [4 points]
- Pain prevents me from sleeping at all. [5 points]

Section 8: Sex Life

(pain = fear of provoking pain)

- My sex life is normal and does not cause pain. [0 points]
- My sex life is normal, but causes some pain. [1 point]
- My sex life is almost normal, but causes severe pain. [2 points]
- My sex life is significantly restricted by pain. [3 points]
- My sex life is almost absent because of pain. [4 points]
- Pain prevents me from having any sex life. [5 points]

Section 9: Social Life

- My social life is normal and does not increase my pain. [0 points]
- My social life is normal, but increases my level of pain. [1 point]
- Pain has no significant effect on my social life, except for more energetic activities such as dancing. [2 points]
- Pain restricts my social life; I cannot go out as often. [3 points]
- Pain restricts my social life to activities at home. [4 points]
- I have no social life because of the pain. [5 points]

Section 10: Travelling

- I can travel anywhere without pain. [0 points]
- I can travel anywhere, but it causes pain. [1 point]
- Pain is present, but I can travel for more than two hours. [2 points]
- Pain restricts me to journeys of less than one hour. [3 points]
- Pain restricts me to essential journeys of under 30 minutes. [4 points]
- Pain prevents me from travelling except to see a doctor or go to hospital. [5 points]

Scoring Interpretation

0–20% → Minimal disability.

Patients can manage most daily activities. Education on posture and lifting is usually sufficient; special treatment is rarely required.

21–40% → Moderate disability.

Pain is more pronounced during sitting, standing, and lifting. Travel and social activities may be impaired. Conservative treatment is usually appropriate.

41–60% → Severe disability.

Pain is the main problem and significantly limits daily activities. These patients require detailed assessment.

61–80% → Crippled.

Pain affects all aspects of life. Active intervention is required.

81–100% → Bed-bound or symptom exaggeration.

Patients are either confined to bed or may be significantly magnifying their symptoms.

13.3. Informed Consent Sample

Informed consent is a fundamental requirement for any clinical or scientific research involving human subjects, safeguarding ethical standards and participants' rights. In this study, the informed consent process was designed to provide all participants with comprehensive information about the study's objectives, planned procedures, possible risks (e.g., discomfort, temporary symptom exacerbation), and anticipated benefits. All subjects had the opportunity to ask questions prior to signing.

The consent form included the following key elements:

- A clear explanation of the purpose, duration, and main phases of the study.
- A detailed description of the types of data to be collected and how the data would be used.
- Emphasis on voluntary participation—participants could withdraw consent and discontinue their involvement at any time, without consequences.
- Written assurance of confidentiality and anonymity; personal information would not be shared with third parties or used to identify participants.
- Statement clarifying that results would only be published in aggregate, anonymous form, without personal identifiers.
- Contact details for the responsible investigator, should participants have questions or wish to withdraw consent.

Before entering the study, each participant was provided with a written informed consent form, which they read and signed independently. By doing so, they officially authorized data collection, processing, and subsequent anonymous publication of study results. This approach complies with the ethical principles of the Declaration of Helsinki and current legal regulations.

13.3.1. Example of the informed consent read and signed by every patient who participated in the study in English

BIOMEDICAL RESEARCH ETHICS COMMITTEE INFORMED CONSENT

The informed consent form was drawn up in accordance with the Law on Health Care of the Republic of Croatia (OG 158/08, 71/10, 139/10, 22/11, 84/11, 12/12, 35/12, 70/12 and 82 / 13) and the Law on the Rights of Patients of the Republic of Croatia (Official Gazette 169/04, 37/08)).

1. FULL NAME OF THE SCIENTIFIC RESEARCH/PROJECT?

Research title -

The exact name of the institution where the research is conducted -

Source of financing -

Estimated duration of the research -

2. CALL FOR PARTICIPATION?

Dear Sir or Madam,

We invite you to participate in a scientific study to investigate_____.

This notice will provide you with information intended to help you decide whether you want to participate in this scientific research. Therefore, please read carefully. For any questions

or concerns, please contact the researcher who handed you this notice, or the member of the research team in charge of communication with the respondents.

3. GOAL / PURPOSE AND PLAN OF SCIENTIFIC RESEARCH?

Hypothesis and goals:

Research plan:

4. YOUR ROLE AS RESPONDENT IN THIS RESEARCH?

Your role in this research is your voluntary participation as a patient in the rehabilitation process, whereby you are randomly selected. The research will be conducted in the

5. WHAT ARE THE POSSIBLE ADVANTAGES OF PARTICIPATION FOR YOU AS THE RESPONDENT?

There is no guarantee that you will personally benefit from participating in the research. However, there is a great possibility that your condition will improve or reduce the pain in the area of the lumbar spine. You and this research can help in finding a better or more effective therapeutic procedure for lumbar spine pain syndrome.

6. WHAT ARE THE POSSIBLE RISKS OF PARTICIPATING IN THIS RESEARCH?

Possible side effects that may occur in this research are minimal reactions to physical therapy in the form of a change in pain intensity at the beginning of therapy.

7. ARE THERE ALTERNATIVE DIAGNOSTIC OR THERAPEUTIC METHODS?

There are other approaches to treating your disease. You can discuss this with the principal investigator and other collaborators. You do not have to participate in this research to receive therapy to treat your disease.

8. DOES ONE HAVE TO PARTICIPATE?

Your participation in this research is voluntary! You can withdraw freely and without any consequences at any time, without giving a reason. You will continue to be treated in the way that is usual for your disease. It is solely up to you to decide whether you want to participate in this research. You give your consent to participate by signing the last page of this form (one copy). If at any time you decide to end your participation, please inform the principal investigator and/or his collaborators.

9. CONFIDENTIALITY AND INSIGHT IN MEDICAL DOCUMENTATION?

Your personal/medical data will be collected in accordance with ethical and bioethical principles, and your privacy (medical confidentiality) and data confidentiality protection will be ensured. Data will be processed electronically, and the principal investigator and his collaborators will follow internal procedures for the protection of personal/medical data. You will be entered into the database using a code. Your name will never be revealed. Your medical records will be reviewed by the principal investigator and his associates. The representatives of the ethics committee of the Drinković polyclinic where you are being treated and the ethics committee of the Faculty of Medicine in Rijeka can have access to the documentation.

10. WHAT WILL THE DATA OBTAINED IN THIS SCIENTIFIC RESEARCH BE USED FOR?

Data from this scientific research can be of scientific and professional use. Therefore, it will be published in scientific and/or professional publications. Your identity will remain anonymous.

11. WHO ORGANIZES AND FINANCES THIS RESEARCH?

The research is organized and financed

12. WHO REVIEWED THE APPLICATION OF THIS RESEARCH?

The application for this research was reviewed

13. WHO TO CONTACT FOR FURTHER INFORMATION?

If you have any questions or concerns, or need additional information about this research, please feel free to contact the principal investigator or his collaborators:

Name and surname of the main researcher:

Address:

Phone number:

e-mail address:

14. WHO ELSE TO INFORM ABOUT THIS RESEARCH?

If necessary, we can inform your family doctor about your participation in this scientific research.

15. ON WRITTEN CONSENT FOR PARTICIPATION IN RESEARCH?

You will receive a copy of the form that you will sign if you want to participate in the research. The original copy of the Informed Consent to participate in the research form will be kept and kept by the principal investigator.

16. LEGAL FRAMEWORKS?

This research is conducted in accordance with all applicable guidelines, the aim of which is to ensure the proper conduct of the research and the safety of the persons participating in this scientific research respecting the Basics of Good Clinical Practice. The research will ensure compliance with fundamental ethical and bioethical principles – personal integrity (autonomy), justice, beneficence and harmlessness – in accordance with the Nuremberg Code and the latest revision of the Declaration of Helsinki.

I confirm that I am (date)....., in, read the Informed Consent, and I had the opportunity to ask questions.

I understand that my consent to the proposed research is voluntary, and I can withdraw at any time, without giving a reason and without any health or legal consequences.

I understand that responsible individuals have access to my medical documentation, i.e. the principal investigator and his associates, members of the Ethics Committee of the institution where the procedure is performed, and members of the Ethics Committee that approved this scientific research. I give permission to these individuals to access my medical records.

I agree that my family doctor and a family member authorized by me will be informed of my participation in the above-mentioned scientific research.

I agree to participate in the research.

Name and surname of the patient:

Name and surname (block letter)

Signature:

Date: _____

Name and surname of parents/relatives/guardians:

Name and surname (block letter)

Signature:

Date: _____

Doctor's name and surname:

Name and surname (block letter)

Signature: _____

Date: _____

13.3.2. Original informed consent of the patient in Croatian

Braće Branchetta 20
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fax: +385 (051) 675 806
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ETIČKO POVJERENSTVO ZA BIOMEDICINSKA ISTRAŽIVANJA INFORMIRANI PRISTANAK

Obrazac informiranog pristanka, je sastavljen u skladu sa Zakonom o zdravstvenoj zaštiti Republike Hrvatske (NN 158/08, 71/10, 139/10, 22/11, 84/11, 12/12, 35/12, 70/12 i 82/13) i Zakonom o pravima pacijenata Republike Hrvatske (NN 169/04, 37/08)).

1. PUNI NAZIV ZNANSTVENOG ISTRAŽIVANJA/PROJEKTA

Naziv znanstvenog istraživanja –

Točan naziv ustanove u kojoj se provodi istraživanje –

Izvor financiranja –

Predviđeno trajanje istraživanja –

2. POZIV NA SUDJELOVANJE

Poštovana/poštovani,

pozivamo Vas da sudjelujete u znanstvenom istraživanju u kojem će se istražiti

Ova obavijest će Vam pružiti podatke čija je svrha pomoći Vam odlučiti želite li sudjelovati u ovom znanstvenom istraživanju. Zato Vas molimo da ju pažljivo pročitate. Za sva pitanja ili

nedoumice, obratite se istraživaču koji Vam je uručio ovu obavijest, ili članu istraživačkog tima zaduženom za komunikaciju s ispitanicima.

3. CILJ /SVRHA I PLAN ZNANSTVENOG ISTRAŽIVANJA

Hipoteza i ciljevi:

Plan istraživanja:

4. VAŠA ULOGA KAO ISPITANIKA U OVOM ISTRAŽIVANJU

Vaša uloga u ovom istraživanju je dobrovoljno sudjelovanje Vas kao pacijenta u procesu rehabilitacije, pri čemu ste nasumično odabrani. Istraživanje će se provoditi

5. KOJE SU MOGUĆE PREDNOSTI SUDJELOVANJA ZA VAS KAO ISPITANIKA?

Ne postoji jamstvo da ćete Vi osobno imati koristi od sudjelovanja u istraživanju. Međutim, postoji velika mogućnost da se Vaše stanje poboljša odnosno smanji bol na području lumbalne kralježnice. Vi i ovo istraživanje može pomoći u nalaženju boljeg odnosno najučinkovitijeg terapijskog postupka kod lumbalnog bolnog sindroma kralježnice.

6. KOJI SU MOGUĆI RIZICI SUDJELOVANJA U OVOM ISTRAŽIVANJU?

Moguće nuspojave koje se mogu javiti u ovom istraživanju su minimalne reakcije na provođenje fizikalne terapije u vidu promjene intenziteta boli na početku terapije.

7. POSTOJE LI ALTERNATIVNE DIJAGNOSTIČKE ILI TERAPIJSKE METODE?

Postoje i drugi pristupi liječenju Vaše bolesti. O tome možete razgovarati s glavnim istraživačem i ostalim suradnicima. Ne morate sudjelovati u ovom istraživanju da biste primali terapiju za liječenje Vaše bolesti.

8. MORA LI SE SUDJELOVATI?

Vaše sudjelovanje u ovom istraživanju je dobrovoljno! Možete se slobodno i bez ikakvih posljedica povući u bilo koje vrijeme, bez navođenja razloga. Nastavit ćete se dalje liječiti na način koji je uobičajen za Vašu bolest. Isključivo na Vama je da odlučite želite li sudjelovati u ovom istraživanju. Svoj pristanak na sudjelovanje dajete potpisivanjem posljednje stranice ovog obrasca (jedan primjerak). Ako u bilo kojem trenutku odlučite prekinuti sudjelovanje, molimo da o tome obavijestite glavnog istraživača i/ili njegove suradnike.

9. POVJERLJIVOST I UVID U MEDICINSKU DOKUMENTACIJU?

Vaši će osobni/medicinski podaci biti prikupljeni u skladu s etičkim i bioetičkim principima, te će se osigurati Vaša privatnost (medicinska tajna) i zaštita tajnosti podataka. Podaci će se obrađivati elektronički, a glavni istraživač i njegovi suradnici pridržavat će se interne procedure za zaštitu osobnih/medicinskih podataka. U bazu podataka biti ćete uneseni pomoću koda. Vaše ime nikada neće biti otkriveno. Vašu medicinsku dokumentaciju će pregledavati glavni istraživač i njegovi suradnici. Pristup dokumentaciji mogu imati predstavnici

10. ZA ŠTO ĆE SE KORISTITI PODACI DOBIVENI U OVOM ZNANSTVENOM ISTRAŽIVANJU?

Podaci iz ovog znanstvenog istraživanja mogu biti od znanstvene i stručne koristi. Stoga će se objavljivati u znanstvenim i/ili stručnim publikacijama. Vaš identitet će ostati anoniman.

11. TKO ORGANIZIRA I FINANCIRA OVO ISTRAŽIVANJE?

Istraživanje organizira i financira

12. TKO JE PREGLEDAO PRIJAVU OVOG ISTRAŽIVANJA?

Prijavu za ovo istraživanje pregledalo je

nakon uvida u svu potrebnu dokumentaciju i odobrilo istraživanje.

13. KOGA KONTAKTIRATI ZA DALJNJE OBAVIJESTI

U slučaju bilo kakvih pitanja ili nedoumica, ili trebate dodatne podatke o ovom istraživanju, slobodno se obratite glavnom istraživaču ili njegovim suradnicima:

Ime i prezime glavnog istraživača:

Broj telefona:

e-mail adresa:

14. KOGA JOŠ OBAVIJESTITI O OVOM ISTRAŽIVANJU?

Ukoliko bude potrebno možemo obavijestiti Vašeg obiteljskog liječnika o Vašem sudjelovanju u ovom znanstvenom istraživanju.

15. O PISMENOJ SUGLASNOSTI ZA SUDJELOVANJE U ISTRAŽIVANJU

Presliku obrasca koji ćete potpisati ako želite sudjelovati u istraživanju, dobiti ćete Vi. Originalni primjerak obrasca Informiranog pristanka na sudjelovanje u istraživanju će zadržati i čuvati glavni istraživač.

16. ZAKONSKI OKVIRI

Ovo istraživanje se provodi u skladu sa svim primjenljivim smjernicama, čiji je cilj osigurati pravilno provođenje istraživanja i sigurnost osoba koje sudjeluju u ovom znanstvenom istraživanju poštujući Osnove dobre kliničke prakse. Istraživanjem će biti osigurano poštivanje temeljnih etičkih i bioetičkih principa – osobni integritet (autonomnost), pravednost, dobročinstvo i neškodljivost – u skladu s Nürnberškim kodeksom i najnovijom revizijom Helsinške deklaracije.

Potvrđujem da sam (datum)....., u, pročitao/pročitala Informirani pristanak, te sam imao/imala priliku postavljati pitanja.

Razumijem da je moj pristanak na predloženo istraživanje dobrovoljan, te se mogu povući u bilo koje vrijeme, bez navođenja razloga i bez ikakvih posljedica po zdravstvenom ili pravnom pitanju.

Razumijem da mojoj medicinskoj dokumentaciji imaju pristup odgovorni pojedinci, tj. glavni istraživač i njegovi suradnici, članovi Etičkog povjerenstva ustanove u kojoj se postupak obavlja, te članovi Etičkog povjerenstva koje je odobrilo ovo znanstveno istraživanje. Dajem dozvolu tim pojedincima za pristup mojoj medicinskoj dokumentaciji.

Pristajem da moj obiteljski liječnik i od mene ovlašteni član obitelji budu upoznati s mojim sudjelovanjem u gore navedenom znanstvenom istraživanju.

Pristajem na sudjelovanje u istraživanju.

Ime i prezime pacijenta:

Ime i prezime (štampano) _____

Potpis: _____

Datum: _____

Ime i prezime roditelja/srodnika/skrbnika:

Ime i prezime (štampano) _____

Potpis: _____

Datum: _____

Ime i prezime liječnika:

Ime i prezime (štampano) _____

Potpis: _____

Datum: _____

14

History of Spine Treatments

14.1 Historical Context and Facts

The history of low back pain treatment reflects the broader evolution of medicine itself, moving from intuitive, symptomatic care to evidence-based, multidisciplinary management. Ancient civilisations recognised low back pain and sciatica as disabling conditions, yet their treatments relied primarily on herbal preparations, manual techniques and rudimentary traction. Over time, these early concepts were preserved, adapted and gradually expanded, particularly during the Islamic Golden Age and the rise of European orthopaedics. The industrial era brought recognition of low back pain as a major occupational and societal issue, prompting new diagnostic approaches and the first structured attempts at spinal stabilisation. The 20th century witnessed transformative developments—from the discovery of lumbar disc herniation and the introduction of spinal fusion to the emergence of microsurgical techniques and advanced imaging. More recently, a shift towards biopsychosocial and evidence-based models has reframed low back pain as a multidimensional condition requiring integrated care. Together, these milestones illustrate how our understanding of spinal disorders has progressively deepened, guiding the therapeutic strategies used today.

14.2 History of Spine Treatments

Period	Event / Development	Key Figures	Significance
Ancient civilisations (c. 1500 BC – 500 AD)	Early descriptions of low back pain; treatment with herbal remedies, massage, traction, cupping and rest in Egyptian, Greek and Roman texts	Anonymous authors of the <i>Edwin Smith Papyrus</i> ; Hippocrates; Galen	Establishes that low back pain and “sciatica” were recognised very early; management was non-specific and largely symptomatic
Middle Ages & Islamic Golden Age (c. 500 – 1500)	Preservation and expansion of Greco-Roman ideas; use of traction, cautery, immobilisation, and herbal medicine for spinal pain and deformity	Avicenna (Ibn Sina), Albucasis and other Arabic–Islamic physicians	Maintains continuity of ancient concepts; focuses on rest, splinting and non-operative measures rather than true spine surgery
19th century (industrial era)	Low back pain recognised as a major occupational problem; belief that pain “comes from the spine” and is often due to injury; rise of orthopaedics, corsets, traction and prolonged bed rest	Early orthopaedic surgeons and industrial physicians	Frames low back pain as a discrete spinal disorder and occupational disease; sets the stage for modern diagnostic and surgical thinking
Early 20th century (c. 1900 – 1930)	Introduction of spinal fusion to treat deformity and tuberculosis of the spine; increasing use of X-ray; early attempts at stabilising painful spines	Russell Hibbs, Fred H. Albee	First consistent operative strategy aimed at stabilising diseased or deformed spines, including some patients whose main complaint was pain

1930s – 1960s (disc surgery era)	Identification of lumbar disc herniation as a cause of sciatica; first surgical removal of herniated lumbar discs via laminectomy and durotomy	William Jason Mixter, Joseph Barr	Establishes disc herniation as a surgically treatable cause of low back and leg pain; open discectomy becomes the gold standard for decades
Late 1960s – 1980s (microdiscectomy & imaging)	Introduction of the operating microscope and microsurgical lumbar discectomy; development and adoption of CT and then MRI for spinal imaging	M. Gazi Yasargil, Wolfgang Caspar, later Williams & Wilson; pioneers of CT/MRI	Greatly reduces surgical morbidity and incision size while maintaining efficacy; modern imaging transforms diagnosis of spinal causes of low back pain and radiculopathy
From 1977 onwards (biopsychosocial & multidisciplinary care)	Proposal of the biopsychosocial model; growing emphasis on active rehabilitation, physiotherapy, exercise therapy, behavioural approaches and multimodal pain management for chronic low back pain	George Engel; later spine and pain-medicine researchers (e.g. Waddell, Gatchel, Turk and others)	Re-frames chronic low back pain as an interaction of biological, psychological and social factors; underpins modern guideline-based, non-surgical management strategies
2000s – present (evidence-based, minimally invasive & interventional era)	Refinement of minimally invasive spine surgery, image-guided injections, radiofrequency procedures; stronger evidence-based guidelines for conservative care (exercise, manual therapy, patient education); emerging biologics and regenerative approaches	Multiple surgical and non-surgical spine societies, guideline groups and research consortia worldwide	Consolidates a dual path: high-precision surgery for selected patients and structured, guideline-driven conservative care for the majority with non-specific low back pain

Taken as a whole, the historical progression of low back pain treatment demonstrates a steady movement towards greater precision, safety and scientific grounding. Each era contributed essential insights: the ancients described the condition, mediaeval scholars preserved foundational knowledge, early surgeons experimented with structural solutions, and modern clinicians introduced imaging, minimally invasive techniques and multidisciplinary rehabilitation. Today's approach—anchored in evidence-based guidelines, patient education, active therapy and carefully selected surgical interventions—represents the integration of centuries of accumulated experience. While technological advances continue to refine surgical and interventional options, contemporary understanding emphasises that effective management requires acknowledging biological, psychological and social dimensions alike. The trajectory of history therefore highlights not only how far treatment has advanced, but also the continuing need for holistic, patient-centred strategies in addressing one of the world's most prevalent health problems.

15

Being Happy in Order to Have a Healthy Spine

15.1 The Link Between Happiness and a Healthy Spine

If you engage in any demanding intellectual or physical work, you may have noticed moments when everything seems to flow more naturally. These moments often coincide with a state of happiness—not necessarily one of excitement, but a calm sense of contentment, balance, and inner ease. When you are happy, your mind functions more efficiently: it is clearer, more focused, and more creative. This improved mental state does not only enhance productivity; it also plays an important role in maintaining a healthy spine.

Positive emotions reduce muscle tension, particularly in the neck, shoulders, and lower back—areas that commonly tighten under stress. Chronic tension contributes to poor posture, restricted mobility, and increased strain on the spine. A happier mental state helps break this cycle by lowering stress hormones, improving breathing patterns, and promoting natural, relaxed movement.

Furthermore, people who feel emotionally well are more inclined to take care of themselves: they move more regularly, maintain better posture, engage in strengthening and stretching exercises, and recover more quickly after episodes of pain. Happiness also improves sleep quality, which is essential for tissue repair and spinal health.

In short, emotional wellbeing and spinal health are deeply interconnected. Cultivating happiness—through meaningful relationships, enjoyable activities, physical exercise, mindfulness, or simple moments of rest—is not merely a psychological luxury. It is a practical and scientifically supported component of maintaining a healthy spine and preventing chronic pain.

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Dr. Kosić has authored and co-authored multiple scientific publications, including in *Medical Science Monitor*, and serves as a peer reviewer for *Medical Science Monitor* and the *American Journal of Case Reports*. He actively participates in international conferences and contributes to advancing research in rehabilitation and health sciences.

