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Gait cycle profile in individuals with non-specific low back pain

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ABSTRACT

Background: Lower Back Pain (LBP) is a frequently reported global health issue, LPB can cause biomechanical disturbances in the gait cycle, including reduced speed, increased step asymmetry, and postural stability disturbances, which can increase the risk of falls and decrease the quality of life of the sufferers. This review aimed to explore changes in the gait cycle in individuals with LBP compared to those without LBP, focusing on biomechanical aspects such as spatiotemporal and kinetic parameters.

Methods: This study uses a literature review method. Articles were searched through Pubmed and Google Scholar using the keywords "low back pain," "non-specific low back pain," "gait analysis," and "gait cycle." This literature search employed Boolean logic "OR" and "AND".

Results: The majority of the seven journals reviewed indicate that non-specific low back pain (NSLBP) causes significant changes in the gait cycle, including decreased speed and stride length, increased movement asymmetry, and reduced trunk variability and stability. These changes are influenced by pain, motor control disturbances, biomechanical compensation, and psychological factors such as kinesiophobia.

Conclusion: This literature review showed that individuals with non-specific low back pain (NSLBP) experienced significant changes in their gait cycle profile, including reduced stride length, walking speed, joint moments, as well as movement variability and stability.

Keywords: gait analysis, gait cycle, low back pain, non-specific low back pain.

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Introduction

Low back pain (LBP) represents one of the most prevalent public health concerns worldwide.[1,2] According to the Global Burden of Disease Study 2017, the global prevalence of LBP was estimated at 7.5%.[1] Clinically, LBP is characterized by pain accompanied by muscle stiffness or tension, typically localized between the lower rib cage and the buttocks, with or without radiation along the sciatic nerve.[3] If left untreated, this condition may lead to reduced mobility, diminished quality of life, and an increased risk of disability.

LBP has emerged as the leading cause of years lived with disability (YLDs) worldwide, accounting for 64.9 million cases in 2017, surpassing diabetes (38.6 million), chronic obstructive pulmonary disease (30.6 million), and other chronic conditions.[3] Multiple factors, including poor posture, injury, disc degeneration, musculoskeletal disorders, and population aging, contribute to the high prevalence of LBP. A major consequence of LBP is biomechanical disruption, which adversely affects the gait cycle.

The gait cycle is a series of body movements that produce rhythmic, systematic, and coordinated forward movement.[4] Studies show that individuals with LBP experience biomechanical changes during walking, such as reduced walking speed, increased step asymmetry, and impaired postural stability.[5,6] These changes can increase the risk of falling and worsen the quality of life of sufferers.[7] A better understanding of LBP affecting the gait cycle is essential in physical therapy and musculoskeletal rehabilitation.

By understanding these biomechanical changes, specific interventions, such as functional therapy and biofeedback, can be developed to enhance the effectiveness of treatment. Although the relationship between LBP and changes in the gait cycle has been extensively studied, there remain significant variations in the results of previous research.[6] Therefore, further research is needed to integrate biomechanical analysis with psychosocial aspects to comprehensively understand the impact of LBP on the gait cycle. This review aims to explore changes in the gait cycle in individuals with LBP compared to those without LBP, focusing on biomechanical aspects such as spatiotemporal and kinetic parameters. This understanding is expected to provide comprehensive insights into the relationship between LBP and the gait cycle, as well as support the development of more effective rehabilitation strategies, including neuromuscular-based interventions and biomechanical-psychosocial approaches.

Methods

This study uses a literature review method. The research was conducted using secondary data from scientific articles obtained through PubMed and Google Scholar. Literature search was conducted using keywords such as "low back pain," "nonspecific low back pain," "gait," and "gait cycle" combined with Boolean operators. The Inclusion criteria included articles published within the last 10 years, from credible peer-reviewed journals, using quantitative, experimental, observational, or cross-sectional study designs, and discussing gait cycle characteristics in individuals with non-specific LBP. Exclusion criteria include studies on specific LBP, articles older than 10 years, reviews, editorials, letters to the editor, conference abstracts, or articles without full access, and studies that do not mention or analyze gait cycle parameters. Data was extracted by summarizing data grouped in a table including journal authors, journal titles, research methods, and research results.

Results

Based on an analysis of seven reviewed journals, it was found that the majority of studies showed significant changes in gait cycle profiles in individuals with NSLBP. Six of the seven journals reported that NSLBP was associated with changes in gait parameters such as reduced walking speed, shorter stride length, increased movement asymmetry, and reduced trunk variability and stability during walking. These changes are primarily caused by pain, motor control impairments, biomechanical compensation, and psychological factors such as kinesiophobia.

Specifically, Karimi et al., compared kinematic and kinetic gait analysis between individuals with non-specific chronic low back pain (NCLBP) and healthy individuals. Although no significant differences were found in spatiotemporal parameters and joint range of motion (ROM), the study showed that NCLBP patients experienced reduced moments at the hip, knee, and ankle joints.[8]

Castro-Méndez et al., conducted a study using the OptoGait system (an optical gait analysis tool) to analyze spatiotemporal gait parameters in patients with chronic low back pain (CLBP) and a healthy control group. The results showed that CLBP patients experienced significant changes in step length, walking speed, and cadence.[9]

Research by Zheng et al investigated the relationship between central sensitization (CS) or increased neuronal response in the central nervous system to sensory stimuli and gait characteristics in patients with CLBP using a machine learning approach and data from accelerometers worn for one week during daily activities. The results showed that patients with high CS levels exhibited more regular, less variable, and more predictable gait patterns, reflecting rigid and protective motor control strategies. Conversely, patients with low CS levels demonstrated more adaptive and flexible motor control strategies, characterized by smoother and more stable gait patterns. This study emphasizes that these differences in motor strategies reflect the body's response to increased pain sensitivity.[10]

In Nishi et al. study explored trunk variability and stability during walking in CLBP patients both in the laboratory and in real-life environments. Using accelerometers, they found that CLBP patients exhibited reduced trunk variability and stability, particularly in unstructured environments. These findings suggest that the environment influences motor control and that these changes are closely related to pain intensity, fear of movement (kinesiophobia), and reduced quality of life.[11]

Chinpeerasathian et al., compared lower extremity kinematics between individuals with NCLBP and healthy individuals. Using 3D motion analysis and dividing the stance phase into four subphases, it was found that the NCLBP group experienced reduced movement in the hip and knee joints and increased movement in the rearfoot (back heel). Additionally, their walking speed was significantly slower. These changes reflect biomechanical adaptations to pain, which may be caused by motor limitations, neuromuscular control dysfunction, and protective strategies to avoid pain during walking.[12]

The study by Lee & Sung (2021) focused on comparing movement asymmetry between individuals with NCLBP and healthy individuals using the kinematic similarity index (KSI), a quantitative measure used to assess the similarity of movement patterns (kinematics) between two conditions or between different individuals. The results showed that individuals with NCLBP had lower levels of bilateral movement similarity, particularly during the midstance and swing phases. These findings indicate that neuromuscular control impairments in NCLBP patients lead to unbalanced or asymmetrical walking patterns, which impact the efficiency and stability of their gait. This index can be used to detect and monitor quantitative changes in gait function in a clinical context.[13]

Meanwhile, research by Tsigkanos et al (2021) used a non-linear approach to evaluate pelvic and lumbar spine movement variability during walking in patients with LBP. Using the Maximal Lyapunov Exponent (LyE), a measure of dynamic stability of the musculoskeletal system, and Approximate Entropy (ApEn), a measure of complexity and predictability of time-series patterns in walking movements, it was found that individuals with LBP exhibited lower movement variability compared to the healthy control group. These findings suggest that LBP patients develop a stiffer walking pattern, likely as a protective response to pain, thereby reducing their ability to adapt to disturbances.

Table 1. Results summary of the gait cycle profile in individuals with non-specific low back pain

Authors	Study Design	Population	Sample Size	Methods	Main Results
Karimi *et al*. (2025)[8]	Cross-sectional	Patients with NSCLBP and healthy individuals	40	3D motion analysis, GRF (Ground Reaction Force)	There was a decrease in joint moment or a reduction in the rotational force exerted by the muscles on the hip, knee, and ankle joints in NSLBP patients compared to controls.
Castro-Méndez *et al*. (2021)[9]	Case–control	CLBP patients and healthy individuals	147 (75 vs 72)	OptoGait – spatiotemporal analysis	There were significant changes in stride length, stride rate, and cadence in the CLBP group compared to the control group.
Zheng *et al*. (2022)[10]	Observational	CLBP patients (with/without CS)	42	Accelerometer + machine learning	CLBP groups with high central sensitization, or increased neuronal response in the central nervous system to sensory stimuli, exhibit a gait pattern that is more rigid, more regular, but less varied and stable.
Nishi et al. (2021)[11]	Cross-sectional	CLBP patients and controls	40 (20 vs 20)	Accelerometer in daily environment	Trunk movement variability and stability were significantly reduced in real-life environments compared to laboratory settings.
Chinpeerasathian et al. (2023)[12]	Cross-sectional	CNLBP and healthy patients	26 (13 vs 13)	3D motion analysis, marker	A decrease in sagittal movement in the hip and knee was found, as well as an increase in frontal movement in the rearfoot. Walking speed also decreased.
Lee & Sung (2021)[13]	Case–control	NSCLBP patients and healthy individuals	41 (22 vs 19)	Kinematic Similarity Index (KSI)	KSI was lower in the NSLBP group, particularly in the midstance and swing phases.
Tsigkanos et al. (2021)[14]	Cross-sectional	LBP patients and healthy subjects	29 (16 vs 13)	Entropy & Lyapunov of the pelvis	Pelvic and lumbar motion variability was lower in the LBP group than in the control group, as measured by Lyapunov Exponent and Approximate Entropy, indicating rigid motor control.

This study emphasizes the importance of considering movement quality, not just quantity, in rehabilitation approaches.[14]

Overall, these findings suggest that NSLBP affects movement quality and postural stability during walking, with variations in results influenced by measurement methods, environmental conditions, and the clinical status of each subject. Supporting tables or graphs can be used to clarify these patterns of change and aid in the development of targeted rehabilitative interventions.

Discussion

The findings from the reviewed studies indicate that non-specific low back pain (NSLBP) affects not only basic gait parameters, such as walking speed and stride length, but also involves complex alterations in kinetic aspects, postural stability, and neuromuscular coordination. These changes appear to represent adaptive responses to pain and motor control impairments. Reductions in walking speed, stride length, and movement variability reflect compensatory strategies aimed at minimizing pain, consistent with the fear-avoidance theory. These findings are in agreement with previous research, such as that conducted by Lamoth and Hodges, which confirmed that chronic low back pain (CLBP) impairs movement coordination and stability. Variability across studies may be explained by differences in measurement methods (laboratory-based vs. real-world settings), participant characteristics, psychosocial influences, and the presence of central sensitization.[15]

Spatiotemporal gait alterations are closely associated with reduced joint moments at the hip, knee, and ankle.[16] The inability of major lower limb muscles to generate sufficient force results in slower and stiffer walking patterns. Notably, these reductions in joint moments are not solely attributable to muscle weakness but also represent protective strategies of the nervous system to limit potentially painful movements. The relationship between spatiotemporal and kinetic variables highlights the need for physiotherapy interventions that address not only muscle strengthening but also retraining of motor recruitment patterns.[17]

Bilateral movement asymmetry, as identified through the kinematic similarity index (KSI), reflects imbalances in load distribution across the body. Clinically, this imbalance may accelerate musculoskeletal tissue degeneration due to uneven loading while simultaneously reducing dynamic stability during walking.[18,19] The interaction between asymmetry and reduced joint moments suggests a pathological cycle: muscle weakness contributes to uneven load distribution, and persistent asymmetry further compromises biomechanical efficiency. Correcting asymmetry through balance-based and neuromuscular control exercises is therefore essential to interrupt this cycle.[20,21]

Trunk variability and stability serve as critical indicators of postural control quality. Reduced trunk variability in patients with NSLBP reflects a more rigid motor pattern, which may lower the risk of sudden pain-inducing movements but simultaneously limits adaptive flexibility in response to environmental challenges.[22,23] This issue is particularly pronounced in unstructured real-world settings that require dynamic motor responses. The interaction between trunk stability and spatiotemporal parameters suggests that impairments in proximal segments (the trunk) exert cascading effects on distal movement patterns (the lower extremities).[24]

Psychological factors, particularly kinesiophobia, further reinforce gait rigidity. Fear of movement prompts patients to adopt stiffer and more asymmetrical motor strategies, thereby exacerbating the reduction in movement variability. This finding underscores the strong interrelationship between psychological and biomechanical variables. Thus, while gait alterations can be quantified through kinematic analysis, their underlying mechanisms are not purely mechanical but also psychosocial. Consequently, rehabilitation for patients with NSLBP should not rely exclusively on physical exercise but should also incorporate education and behavioral interventions.[25]

From a neurophysiological perspective, central sensitization (CS) plays a key role in explaining why some patients exhibit more rigid and predictable gait patterns. CS heightens the sensitivity of the central nervous system to painful stimuli, promoting defensive and protective motor strategies. Patients with high levels of CS tend to demonstrate monotonous and less adaptive movement patterns, whereas those with lower CS levels are better able to maintain motor flexibility. The association between CS and reduced trunk variability supports the notion that neurophysiological mechanisms amplify existing biomechanical impairments.[26]

Taken together, gait disturbances in NSLBP arise from the complex interplay of biomechanical, neurophysiological, and psychosocial factors. The reviewed studies are strengthened by the application of advanced gait analysis technologies, such as three-dimensional motion capture and accelerometers, which provide high measurement validity for spatiotemporal and kinematic parameters. However, limitations including heterogeneous study designs, small sample sizes, variability in participant characteristics, and the predominance of observational studies without long-term interventions restrict the generalizability of the findings. Clinically, these results emphasize the importance of multidimensional physiotherapy interventions, including stabilization training, muscle strengthening, fear-avoidance management, and wearable technology-based monitoring. Future research should focus on long-term experimental designs and evaluations within real-world contexts to enhance functional relevance and rehabilitation effectiveness.

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Conclusions

This literature review shows that individuals with NSLBP experience significant changes in the gait cycle, such as a decrease in stride length, walking speed, joint moment, as well as movement variability and stability. These changes are related to compensation for pain, motor control disorders, and psychosocial factors such as fear-avoidance and central sensitization. These findings are important for physiotherapy in designing more comprehensive and contextual interventions. Further research is recommended using stronger experimental designs, larger and more representative samples, and considering additional variables such as psychological conditions, daily activities, and sensor-based monitoring technology. This review is expected to serve as a scientific foundation for the development of research and clinical practice in gait rehabilitation for patients with NSLBP.

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Conflict of interest

The authors declare that there are no potential conflicts of interest, financial or otherwise, that could be construed as influencing the research, the preparation of the manuscript, or the publication and dissemination of this manuscript. All authors affirm that their participation in this study and the preparation of this manuscript were conducted with the highest scientific integrity and without external pressures or personal interests that could compromise the objectivity or validity of the reported findings.

Author contributions

IKR developed the study design, conducted data collection, and prepared the initial manuscript; GPK and MW were responsible for data collection and provided revisions to the manuscript.

Ethical consideration

This review study utilized publicly available published articles, so informed consent and ethical approval were unnecessary.

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