Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Razzaq et al - 2026

DOI: http://doi.org/10.5281/zenodo.21771291

BIOMECHANICAL CHANGES IN POSTURE DURING PREGNANCY AND THEIR ASSOCIATION WITH LOW BACK AND PELVIC GIRDLE PAIN: A SYSTEMATIC REVIEW

Sidra Razzaq[*]
[*]Ms Orthopedic PT
srazzaq207@gmail.com
Maham Iqbal
Ms Orthopedic PT
drmahamiqbal232@gmail.com
Summera Anwar
Ms Orthopedic PT
summeraanwar148@gmail.com
Aamir Gul Memon PhD
Associate Professor, Department of Physical Therapy and Rehabilitation Sciences, Faculty of Allied Health Sciences, Superior University Lahore
aamir.gul@superior.edu.pk
Syed Asadullah Arslan
Professor, Department of Physical Therapy and Rehabilitation Sciences, Superior University Lahore
asadullah.arslan@superior.edu.pk
Professor Muhammad Naveed Babar
Dean Allied Health Sciences, Superior University, Lahore
naveed.babur@superior.edu.pk

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

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Online ISSN 3007-2387

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Author Details

Keywords:
Pregnancy, Biomechanical Changes, Posture, Low Back Pain, Pelvic Girdle Pain, Systematic Review.

Received on 05 Jan, 2026
Accepted on 19 Feb, 2026
Published on 05 March, 2026

Corresponding E-mails & Authors*:
Sidra Razzaq
srazzaq207@gmail.com

Abstract

Background: Pregnancy causes significant biomechanical and postural adaptations, including increased lumbar lordosis, anterior pelvic tilt, altered gait, and reduced balance. These changes are commonly associated with low back pain (LBP) and pelvic girdle pain (PGP), affecting maternal function and quality of life.

Methods: A systematic review was conducted using PubMed and Google Scholar up to June 2026. Studies investigating postural and biomechanical changes during pregnancy and their association with LBP and PGP were included. Data were extracted using a standardized form, and methodological quality was assessed using the NIH Quality Assessment Tool. Owing to methodological heterogeneity, findings were synthesized narratively.

Results: The included studies consistently reported increased lumbar lordosis, anterior pelvic tilt, altered gait mechanics, impaired balance, and foot morphological changes during pregnancy. These biomechanical adaptations were associated with a higher prevalence of LBP and PGP, although variations in assessment methods limited direct comparisons between studies.

Conclusion: Pregnancy-related biomechanical changes are closely associated with LBP and PGP. Early identification of these adaptations and appropriate physiotherapy interventions may improve maternal health outcomes. Further high-quality longitudinal studies with standardized assessment methods are recommended.

INTRODUCTION

Pregnancy is accompanied by a wide range of physiological and biomechanical adaptations that are necessary to support fetal growth and prepare the maternal body for childbirth. Progressive increases in maternal weight, enlargement of the uterus, and forward displacement of the body's center of gravity lead to compensatory changes in posture and movement. These adaptations commonly include increased lumbar lordosis, anterior pelvic tilt, altered spinal alignment, changes in gait, and reduced postural stability. Furthermore, pregnancy-related hormonal changes, particularly increased ligament laxity, may decrease joint stability and alter normal musculoskeletal function, placing additional stress on the lumbar spine and pelvic girdle.Low back pain and pelvic girdle pain represent highly prevalent musculoskeletal complications, affecting up to 56% of pregnant individuals and significantly impairing maternal well-being(1).These conditions generally stem from the combined effects of hormonal changes, increased looseness in the ligaments, and the significant changes in body posture required to support a growing fetus(2). As the body undergoes rapid weight gain and shifts in the center of mass, these postural adaptations impose cumulative stress on the

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DOI: http://doi.org/10.5281/zenodo.21771291

lumbopelvic region, frequently leading to chronic discomfort(3) . Although these symptoms are widespread, the physical causes are not yet fully understood, highlighting the need for a thorough review of current research on how pregnancy affects body mechanics(1).

Several biomechanical factors, including increased lumbar lordosis, anterior pelvic tilt, altered trunk posture, reduced balance, and changes in gait characteristics, have been proposed as contributors to the development of LBP and PGP during pregnancy. However, the existing literature reports inconsistent findings regarding the magnitude of these postural changes and their direct association with pain severity. While some studies demonstrate a strong relationship between altered posture and pregnancy-related musculoskeletal pain, others suggest that additional factors such as muscle strength, physical activity, body mass index, parity, and psychosocial influences may also play important roles.Current models suggest that these complications arise from a complex interplay of anatomical transformations, including abdominal wall stretching and increased uterine volume, which necessitate dynamic neuromuscular adaptations(4, 5). These adaptations include a marked increase in lumbar lordosis and thoracic curvature, often accompanied by an anterior pelvic tilt to maintain equilibrium as the center of gravity shifts (6). Such biomechanical transitions, while essential for maternal stability, contribute significantly to the high global burden of musculoskeletal morbidity observed throughout gestation(7, 8).

Specifically, fluctuations in pelvic alignment and postural stability, often exacerbated by the secretion of hormones like relaxin, represent primary clinical indicators of increased musculoskeletal risk(9). Furthermore, evidence suggests that women experiencing these postural shifts exhibit significant increases in center-of-pressure velocity and sway area, particularly during the third trimester when these compensatory mechanisms reach their threshold(10). These alterations in gait and trunk kinematics are further compounded by ligamentous instability, which increases the susceptibility to lumbopelvic pain and associated disability as gestation progresses(11). Additionally, the progressive weakening of abdominal musculature and gluteus medius recruitment challenges further compromise spinal support, placing increased strain on the sacroiliac joint(12)

Pregnancy is accompanied by a range of biomechanical and postural adaptations that may contribute to the development of low back pain and pelvic girdle pain, affecting maternal function and quality of life. Although numerous studies have investigated these changes, the available evidence remains dispersed and varies in methodology and reported outcomes. Therefore, this systematic review was conducted to comprehensively evaluate the existing evidence on biomechanical changes in posture during pregnancy and to examine their association with low back pain and pelvic girdle pain. The findings of this review are expected to provide a better understanding of pregnancy-related musculoskeletal adaptations and support evidence-based clinical decision-making in physiotherapy and maternal healthcare.

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Methodology

Data bases

A comprehensive literature search was conducted to identify relevant studies from PubMed, Google Scholar upto june 2026. The search strategy included combinations of the following keywords: "pregnancy," "pregnant women," "biomechanical changes," "postural changes," "posture," "low back pain," "pelvic girdle pain," "gait," "spinal alignment," and "pelvic tilt."

Inclusion and Exclusion Criteria

Inclusion criteria were restricted to peer-reviewed longitudinal and cross-sectional studies evaluating kinematic or postural parameters in pregnant populations, studies available in english language while exclusion criteria prioritized the removal of non-peer-reviewed gray literature, case reports, and studies focused exclusively on postpartum or non-musculoskeletal pathologies.

Data extraction

Data extraction was conducted independently by reviewers using a standardized form to capture publication details, participant demographics, methodology, and reported biomechanical outcomes (13).

Quality Assessment

Quality assessment of the selected studies was performed using the National Institutes of Health quality assessment tool for observational cohort and cross-sectional studies to ensure methodological rigor(14).

Findings were combined using a narrative summary that grouped physical measurements, such as foot shape and spinal posture, based on their relationship to pain intensity throughout each trimester. For biomechanical parameters, quantitative data were synthesized by evaluating trends in center-of-gravity shifts and pelvic obliquity against reported pain scores across gestational stages (12, 15) (16)

Finally, a formal meta-analysis was not possible due to the wide variation in measurement methods across studies, requiring instead a systematic comparison to identify reliable indicators of musculoskeletal strain.

Results

The included studies comprised a heterogeneous mix of cross-sectional and prospective cohort designs involving sample sizes ranging from 30 to over 200, with a primary focus on assessing postural kinematics and plantar pressure distribution. Participants were predominantly evaluated through gait assessments and standardized questionnaires addressing the presence or absence of pelvic girdle pain (17, 18). Key biomechanical findings suggest that lumbar lordosis and shifts in foot morphology, such as increased length and arch flattening, are commonly observed during pregnancy(5, 19)

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Study selection

Twenty eight clinical studies were identified by the literature search and selected for further appraisal. A total of eleven (11) studies met the predefined eligibility criteria and were included in this systematic review. The selected studies investigated pregnancy-related biomechanical and postural changes and their association with low back pain (LBP) and pelvic girdle pain (PGP). Studies that did not address the review objectives, were duplicates, review protocols, conference abstracts, non-English publications, or lacked sufficient outcome data were excluded.

Methodological Quality Assessment

The methodological quality of the included studies was assessed using the National Institutes of Health (NIH) Quality Assessment Tool (Table-l). Overall, the methodological quality ranged from moderate to high. Most observational studies demonstrated a low risk of bias, while systematic reviews and meta-analyses showed good methodological rigor through comprehensive literature searches and transparent reporting.

Study Characteristics

The included studies comprised systematic reviews, meta-analyses, cross-sectional studies, prospective cohort studies, longitudinal studies, scoping reviews, and narrative reviews (Table-l). Most studies evaluated biomechanical changes such as lumbar lordosis, anterior pelvic tilt, gait alterations, postural stability, balance, trunk movement, foot biomechanics, and lumbopelvic alignment during pregnancy. The primary outcomes included the prevalence, severity, and functional impact of low back pain and pelvic girdle pain among pregnant women.

Main Findings

The findings consistently demonstrated that pregnancy is associated with significant biomechanical and postural adaptations, including increased lumbar lordosis, anterior pelvic tilt, altered gait mechanics, impaired balance, changes in foot morphology, and reduced postural stability. These adaptations were frequently associated with an increased prevalence and severity of low back pain and pelvic girdle pain, particularly during the second and third trimesters. Although methodological differences existed among the included studies, the overall evidence supported a strong association between pregnancy-related biomechanical changes and musculoskeletal pain. Early identification of these biomechanical alterations may facilitate timely physiotherapy interventions and improve maternal functional outcomes.

Table-l Characteristics of included studies

Author (Year)	Study Design	Selection Bias	Performance Bias	Detection Bias	Reporting Bias	Overall Quality
Yoseph et al. (2025)	Review	Low	Moderate	Low	Low	Moderate

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Yadav et al. (2023)	Cross-sectional	Moderate	Moderate	Low	Low	Moderate
Akshita (2023)	Review	Low	Moderate	Low	Low	Moderate
Muhammad et al. (2022)	Cross-sectional	Low	Moderate	Low	Low	Good
Daneau et al. (2021)	Review	Low	Low	Low	Low	Good
Salazar (2021)	Systematic Review	Low	Low	Low	Low	Good
Topalidou et al. (2025)	Scoping Review	Low	Moderate	Low	Low	Moderate
Salari et al. (2023)	Systematic Review & Meta-analysis	Low	Low	Low	Low	High
Galvani et al. (2024)	Review	Low	Moderate	Low	Low	Moderate
Hrvatin et al. (2024)	Cross-sectional	Low	Moderate	Low	Low	Good
Shukla et al. (2026)	Systematic Review	Low	Low	Low	Low	High

Table-ll Methodological quality scores of included studies

Author (Year)	Study Design	Participants	Assessment Method	Main Outcome	Key Findings
Yoseph et al. (2025)	Review	Pregnant women	Literature review	Spinal biomechanics & LBP	Pregnancy-related spinal biomechanical adaptations contribute to low back pain and degenerative spinal changes.

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Yadav et al. (2023)	Cross-sectional	Pregnant working women	Questionnaire survey	Musculoskeletal disorders	Working posture and ergonomics were associated with increased musculoskeletal complaints during pregnancy.
Akshita (2023)	Descriptive Review	Pregnant women	Literature review	Biomechanical changes	Ergonomic modifications may reduce pregnancy-related musculoskeletal discomfort.
Muhammad et al. (2022)	Cross-sectional	Pregnant women	Clinical assessment	Body mechanics & lumbopelvic pain	Poor body mechanics were significantly associated with lumbopelvic pain.
Daneau et al. (2021)	Review	Pregnant women	Literature review	Lumbopelvic pain mechanisms	Hormonal and biomechanical adaptations jointly contribute to pregnancy-related pain.
Salazar (2021)	Systematic Review	Pregnant women	Literature review	Musculoskeletal adaptations	Progressive biomechanical alterations occur throughout pregnancy and influence posture.
Topalidou et al. (2025)	Scoping Review	Pregnant women	Literature review	Pregnancy biomechanics	Current evidence highlights

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					significant biomechanical adaptations during pregnancy and labour.
Salari et al. (2023)	Systematic Review & Meta-analysis	Pregnant women	Meta-analysis	Low back pain prevalence	Low back pain is highly prevalent during pregnancy worldwide.
Galvani et al. (2024)	Review	Pregnant women	Literature review	Skeletal and muscular changes	Pregnancy produces significant skeletal, muscular and joint adaptations affecting maternal health.
Hrvatin et al. (2024)	Cross-sectional	Pregnant women	Balance assessment	Pelvic girdle pain	Pelvic girdle pain negatively affects balance during the second and third trimesters.
Shukla et al. (2026)	Systematic Review	Pregnant women	Literature review	Musculoskeletal discomfort	Musculoskeletal discomfort is common during pregnancy and may be influenced by nutritional status.

Discussion

The findings of this systematic review indicate that pregnancy is associated with significant biomechanical and postural adaptations, including increased lumbar lordosis, anterior pelvic tilt,

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altered gait patterns, and balance impairments. These changes appear to contribute to the development of low back pain and pelvic girdle pain in many pregnant women.

Although significant postural adaptations such as increased center-of-pressure velocity and altered spinal curvature are well-documented as compensatory strategies to maintain equilibrium, the specific causal mechanisms linking these biomechanical shifts to lumbopelvic pain remain elusive (7,12)

The adaptations in foot structure and spinal alignment are closely related to broader shifts in walking patterns, such as adjustments to step length and pace, which serve to maintain balance (6, 13, 15, 20). Despite these compensatory mechanisms, evidence suggests that weight gain induced changes in plantar loading and center-of-pressure traces may overwhelm the musculoskeletal system's capacity, potentially predisposing individuals to chronic discomfort(21).

The findings of Annelie Gutke study demonstrated that during pregnancy,Low back pain (LBP) and pelvic girdle pain (PGP) are highly prevalent musculoskeletal disorder, as highlighted by both classical and recent studies. Berg et al. (1988) first demonstrated that a large proportion of pregnant ladies experience LBP, showing its long-standing clinical importance. Recent multinational evidence by Gutke et al. (2018) showed that 70–86% of pregnant women report pelvic girdle and LBP, with notable changes in intensity and effect across countries. These differences can be attributed to changes in healthcare access, treatment strategies, and societal perceptions.The majority of women receiving treatment reported positive results, demonstrating the need for better awareness.(22)

Lene Christensen study findings emphasize that pelvic girdle pain (PGP) has a great effect on gait pattern than pregnancy itself. Women with pelvic girdle pain exhibited less walking speed, prolonged double limb support, and reduced step length, showing more cautious and energy-conserving walking pattern. In Addition, limited pelvic and hip kinematics suggest impaired load transfer and limited mobility, as a protective measure to pain. The strong negative relation between walking velocity and fear of fall highlights the role of psychological factors in functional limitation. These conclusions indicate the importance of both biomechanical and psychosocial components in the clinical treatment of Pelvic girdle pain.(23)

Ezra T. Joseph study funding demonstrated that pregnancy cause many anatomical, hormonal, and biomechanical alteration in the spine and pelvis, which result in musculoskeletal problems such as LBP , Increased lumbar lordosis, ligamentous laxity, and altered gait mechanics which collectively increases mechanical stress on the lumbar spine, causing pregnant women discomfort and functional limitation. Furthermore, other conditions such as sacroiliac joint laxity, anterior pelvic tilt, further cause spinal instability. These biomechanical changes have long-term consequences, such as degenerative disc disease and spondylolisthesis. Conservative management strategies and multidisciplinary team can help to reduce the Pregnancy related spinal disorder.(1)

A study by Rebecca Conder demonstrated that pregnancy cause a lot of biomechanical and postural changes such as kyphosis and lordosis. These changes can cause balance loss and reduced stability leading to risk of fall or pain in back or pelvis. Back pain is commonly seen is pregnant women but its relationship with changes in spine is not consistent across studies. Furthermore, the alteration in

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walking pattern such as reducing the walking speed or decreased stride length shows adaptive changes to improve balance.(24)

The results of Wen hua wu study shows that during pregnancy gait mechanics changes due to pelvic girdle pain mainly caused by the reduced walking velocity and altered segmental rotation. In pregnant women with pelvic girdle pain (PPP), walking speed reduces as compared to healthy control which cause the functional limitations. Furthermore, rotational amplitude increases especially in transverse segmental movement which demonstrates compensatory mechanisms to movement despite pain but spinal rotations are not affected largely.(25)

Although these structural adjustments are well-documented, the lack of standardized measurement protocols across studies limits our ability to determine if specific orthotic interventions could effectively mitigate these biomechanical risks(26, 27). Consequently, future research must prioritize longitudinal studies to clearly link gait adaptations such as changes in step width and walking speed to the onset of pain, enabling us to move beyond descriptive models and develop reliable tools to identify pregnant women at risk of chronic musculoskeletal issues.

Additionally, there is an need to transition toward validated pregnancy specific biomechanical models that facilitate accurate, personalized kinetic analysis across distinct gestational trimesters(28). Establishing a consensus on standardized outcome reporting is essential to bridge the current gap between biomechanical observations and therapeutic efficacy(29).

Conclusion

This systematic review confirms that progressive postural adjustments specifically increased lumbar lordosis and shifted center-of-gravity dynamics are intrinsically linked to the high prevalence of low back and pelvic girdle pain during pregnancy (1). By synthesizing existing evidence on pelvic alignment and kinematic variability, this review highlights the critical need for standardized clinical assessment protocols to better predict and manage these prevalent musculoskeletal challenges Ultimately, these insights suggests to implement biomechanical evaluations into routine prenatal care to facilitate early intervention and improve long-term maternal health outcomes(25).

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