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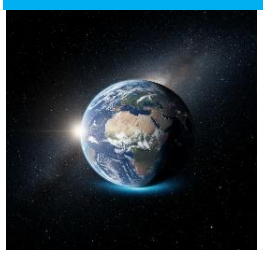

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Effects of Pilates-Based Exercise on Diastasis Recti Abdominis, Pelvic Floor Function, and Musculoskeletal Pain Across the Perinatal Period: A Narrative Review

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Abstract

Introduction: Pregnancy and childbirth induce profound physiological changes affecting posture, abdominal wall integrity, and pelvic floor function. Diastasis recti abdominis affects

approximately 60% of women during pregnancy, pelvic floor dysfunction impacts 30-40% postpartum, and lumbopelvic pain persists in 20-25% of women beyond immediate recovery. Pilates-based exercise offers an integrated approach combining breathing coordination, core activation, and pelvic floor training, theoretically addressing multiple recovery domains simultaneously. Despite growing clinical interest, evidence regarding its effectiveness across the perinatal continuum remains fragmented.

Aim: The purpose of this narrative review is to synthesize current evidence examining the effects of Pilates-based exercise on diastasis recti abdominis, pelvic floor function, and musculoskeletal pain across prenatal and postpartum periods. Particular focus is placed on identifying effective program characteristics, optimal intervention timing, and evidence quality to inform clinical practice and highlight research gaps.

Materials and methods: A comprehensive literature review was conducted using PubMed, Scopus, Web of Science, PEDro, CINAHL, and Cochrane Library databases. Studies published primarily between 2019-2024 were included, emphasizing randomized controlled trials, systematic reviews, and meta-analyses. Search terms included “Pilates,” “pregnancy,” “postpartum,” “diastasis recti,” “pelvic floor,” and “lumbopelvic pain.” Quality assessment utilized the PEDro scale for trials and GRADE criteria for systematic reviews.

Conclusions: Pilates-based exercise demonstrates promise for perinatal musculoskeletal rehabilitation, with evidence supporting reduced perineal trauma and labor pain during pregnancy, measurable reductions in diastasis recti postpartum (−0.30 to −0.65 cm), pelvic floor outcomes comparable to traditional training, and clinically meaningful improvements in lumbopelvic pain. However, significant methodological limitations including small sample sizes, protocol heterogeneity, and contradictory systematic review findings constrain definitive recommendations. Pilates can be recommended as a safe, potentially effective option when delivered by qualified instructors with prenatal/postnatal specialization, appropriately modified for pregnancy stage, and integrated within individualized treatment plans. Future research requires larger, standardized trials with extended follow-up to establish optimal protocols and comparative effectiveness versus established interventions.

Keywords: Pilates, pregnancy, postpartum, diastasis recti abdominis, pelvic floor dysfunction, lumbopelvic pain, perinatal rehabilitation

1. Introduction

Pregnancy and childbirth induce profound physiological and biomechanical changes in the female body, many of which persist into the postpartum period [1,2]. Alterations in posture, increased joint laxity, stretching of the abdominal wall, and weakening of the pelvic floor muscles may contribute to functional limitations, musculoskeletal discomfort, and reduced physical performance after delivery [3,4]. Low back pain, impaired core stability, and pelvic floor dysfunction are among the most commonly reported physical complaints in postpartum women, often affecting their quality of life and ability to return to regular physical activity [5,6].

These postpartum challenges emerge from profound adaptations that occur during pregnancy itself. Pregnancy induces a reduction in the active force of the levator ani muscles, with recent research demonstrating measurable decreases in pelvic floor muscle strength as gestation advances [7]. The expanding uterus elevates intraabdominal pressure while hormonal shifts—particularly increased relaxin—contribute to connective tissue laxity and weakening of the linea alba, creating conditions favorable for diastasis recti development [4,8]. As pregnancy progresses, a decrease is observed in the strength of both the pelvic floor muscles and abdominal muscles, with accompanying changes in posture including anterior pelvic tilt and increased lumbar lordosis [9]. Understanding these pregnancy-related changes is essential for designing effective interventions across the continuum from preconception through postpartum recovery.

Diastasis recti abdominis (DRA), characterized by the widening of the inter-recti distance due to linea alba stretching, affects approximately 60% of women during pregnancy and persists in 45% at six months postpartum and 33% at one year without intervention [8,10]. This separation may compromise core stability and contribute to functional deficits beyond cosmetic concerns. Concurrently, pelvic floor muscle dysfunction affects approximately 30-40% of postpartum women, manifesting as urinary incontinence, pelvic organ prolapse, or sexual dysfunction, with vaginal delivery conferring particularly elevated risk (OR 2.9 for stress urinary incontinence) compared to cesarean delivery [11,12]. Additionally, postpartum low back pain and lumbopelvic pain persist in approximately 20-25% of women beyond the immediate recovery period, limiting physical function and maternal well-being [13,14].

Given the multifactorial nature of postpartum musculoskeletal recovery, exercise-based interventions targeting the integrated core-pelvic floor system have gained clinical attention. Traditional approaches have emphasized isolated pelvic floor muscle training (PFMT) or

abdominal strengthening exercises. However, Pilates-based exercise offers a comprehensive framework integrating controlled breathing, deep core activation, pelvic floor coordination, and postural alignment—theoretically addressing multiple recovery domains simultaneously [15,16].

Despite growing clinical interest in Pilates for perinatal rehabilitation, the evidence base remains fragmented. This review synthesizes current literature examining the effects of Pilates-based exercise on diastasis recti abdominis, pelvic floor function, and postural dysfunction including low back pain across the prenatal and postpartum periods, with emphasis on studies published since 2019 to inform evidence-based clinical practice.

2. Methods

This narrative review examines peer-reviewed literature published primarily between 2019-2024, with emphasis on randomized controlled trials, systematic reviews, and meta-analyses. Electronic database searches included PubMed, Scopus, Web of Science, PEDro, CINAHL, and Cochrane Library using Medical Subject Headings (MeSH) terms and keywords related to Pilates, pregnancy, postpartum, pelvic floor, diastasis recti, and lumbopelvic pain. Studies were included if they examined Pilates-based interventions in prenatal or postnatal populations with outcomes related to diastasis recti abdominis, pelvic floor function, or musculoskeletal pain. Both original research articles and systematic reviews were included to provide comprehensive synthesis of available evidence. Quality of included studies was assessed using appropriate tools including the PEDro scale for randomized controlled trials and GRADE criteria for systematic reviews.

3. Literature review

3.1. Effects of Pilates During Pregnancy on Birth Outcomes and Perineal Protection

Recent evidence demonstrates that Pilates performed during pregnancy provides protective effects beyond prevention of postpartum complications. A quasi-experimental study by Vargas-Terrones et al. [17] involving 72 pregnant women found that participation in a Pilates program significantly reduced perineal trauma during spontaneous deliveries. Women in the experimental group experienced laceration in only 16.7% of cases compared to 54.2% in controls receiving standard antenatal care ($p=0.006$). The frequency of any perineal trauma was

41.7% overall in the sample, but among women who participated in Pilates sessions, this complication occurred in significantly fewer cases (OR 0.17; 95% CI, 0.05-0.57) compared to those receiving only usual antenatal classes (86.7%). Multivariate binary logistic regression analysis confirmed that both episiotomy performance and participation in Pilates sessions exerted protective effects against the occurrence of perineal tearing [17].

The mechanisms underlying these protective effects likely involve continuous strengthening of pelvic floor muscles throughout pregnancy, which increases perineal tissue integrity and resistance during delivery. The duration of training programs appears influential, as physical activity during pregnancy that promotes continuous strengthening of the pelvic floor muscles increases the probability of the perineum remaining intact during childbirth [18]. Additionally, Pilates training emphasizes breathing coordination and visualization techniques that prepare women to manage labor contractions more effectively, potentially reducing excessive straining that contributes to perineal injury. The imaging technique used in Pilates, which involves mental rehearsal of movement patterns, prepares the mother to use this technique during labor [19].

Beyond perineal outcomes, prenatal Pilates demonstrates significant effects on labor progression and pain management. Ghandali et al. [20] conducted a randomized controlled trial with 110 primiparous women who performed Pilates exercises twice weekly for 8 weeks beginning at 26-28 weeks gestation. The intervention consisted of 35-minute sessions including warm-up (5 minutes), pregnancy-specific Pilates exercises (25 minutes), and relaxation (5 minutes). The intervention group experienced significantly reduced labor pain intensity as measured by Visual Analog Scale (VAS), shorter duration of the active phase and second stage of labor, and increased maternal satisfaction with the childbirth process compared to controls ($p<0.05$). The Pilates group reported mean labor pain intensity scores significantly lower than the control group across all stages of labor [20].

A systematic review and meta-analysis by Kolu et al. [21] examined the effect of Pilates exercise on pain during pregnancy and labor. Analysis of two studies revealed that Pilates exercise during pregnancy statistically significantly reduced pain intensity during labor (MD: -1.21, $Z=11.20$, $p<0.00001$). The mechanisms appear multifactorial: studies indicate that regular exercise during pregnancy strengthens the pelvic floor muscles to help relieve pain and reduces the need for epidural anesthesia during labor [22]. Through diaphragmatic breathing techniques, women practicing Pilates during pregnancy can better accommodate uterine contractions and

prenatal pain, facilitating an easier childbirth with reduced labor pain [19]. The improved capability of the trunk and pelvic floor muscles, enhanced flexibility, and proper breathing patterns learned through Pilates may facilitate the delivery process and reduce pain during labor [20].

A recent scoping review by Köse et al. [23] comprehensively analyzed 21 studies examining Pilates effects during pregnancy, confirming improvements across multiple domains including pain management, sleep quality, mental health, urinary incontinence, pelvic floor function, and birth outcomes. The review noted that Pilates significantly reduces pain intensity and improves functional disability when assessed using instruments such as the Oswestry Disability Index [24]. These collective findings underscore the potential benefits of Pilates for both mental resilience and childbirth preparation, with improvements in postural stability, pain management, pelvic alignment, and pelvic floor health, as well as reductions in fear of childbirth [23].

3.2 Preventive Role of Prenatal Exercise

Emerging evidence suggests that exercise performed during pregnancy may influence postpartum diastasis recti abdominis (DRA) outcomes, although findings remain inconsistent. Studies have shown that targeted exercise interventions implemented during the antenatal period may reduce the risk of abdominal muscle separation after childbirth. A systematic review examining the effects of exercise during pregnancy and the postpartum period reported that specific prenatal exercise programs were associated with an approximately 35% reduction in the incidence of DRA [25]. In line with these findings, professional guidelines indicate that abdominal strengthening exercises initiated during pregnancy—particularly drawing-in maneuvers that promote activation of the transversus abdominis—may decrease both the incidence and severity of postpartum DRA following vaginal as well as cesarean delivery [26].

Recent research provides additional support for prenatal exercise effects on postpartum abdominal muscle integrity. Theodorsen et al. [27] conducted a randomized trial demonstrating that pregnant women may exercise both abdominal and pelvic floor muscles during pregnancy without increasing diastasis recti abdominis. This finding challenges previous concerns that abdominal exercise during pregnancy might exacerbate DRA, suggesting instead that appropriate exercise may be safely implemented throughout gestation.

Conversely, broader evidence suggests that general prenatal exercise may not exert a

significant protective effect on DRA outcomes. A large systematic review and meta-analysis including over 52,000 women found no significant association between overall prenatal physical activity and the occurrence of postpartum DRA when potential confounders were controlled for [28]. This discrepancy may be attributable to methodological differences across studies, as interventions focusing on targeted core stabilization—such as Pilates-based exercise or structured transversus abdominis training—appear to demonstrate preventive benefits, whereas general aerobic or mixed exercise programs do not yield specific effects on DRA.

Additionally, the pre-pregnancy condition of the abdominal musculature may play a moderating role in postpartum recovery, with some evidence suggesting that higher baseline core strength could support more favorable outcomes. However, prospective studies directly comparing women who engaged in structured core training prior to pregnancy with those who did not remain limited. The timing and type of exercise appear critical, as interventions emphasizing controlled transversus abdominis activation, coordinated breathing, and pelvic floor engagement show more consistent benefits than general physical activity [29].

Collectively, these findings highlight the potential value of prenatal exercise programs emphasizing controlled transversus abdominis activation and pelvic floor coordination, while underscoring the need for further targeted research to define optimal intervention timing and exercise protocols. Current evidence suggests that Pilates-based approaches, with their integrated focus on deep core activation, breathing coordination, and postural awareness, represent a promising modality for DRA prevention, though larger randomized controlled trials are needed to establish definitive recommendations.

3.3 Effects of Pilates-Based Exercise on Diastasis Recti Abdominis

Pilates-based interventions have been associated with measurable reductions in inter-recti distance (IRD) during the postpartum period. A mat-based Pilates program consisting of 50-minute sessions performed five times per week for 30 days resulted in significant decreases in IRD, as assessed using two-dimensional ultrasonography. Reductions were observed across all measurement sites, ranging from −0.65 cm to −0.30 cm, whereas only minimal changes were reported in the control group (0.06–0.18 cm) [30]. Moreover, a significant reduction in waist circumference (−2.85 cm compared with −0.55 cm in controls; $p = 0.020$) and improvements in abdominal muscular endurance (+8.55 repetitions versus +1.27 repetitions; $p = 0.001$) were shown. No significant changes in rectus abdominis muscle thickness were observed, suggesting

that the observed benefits were primarily attributable to functional rather than hypertrophic adaptations [30].

Comparative research suggests Pilates may offer advantages over alternative approaches. Vidhya Sri et al. [31] demonstrated that Pilates produced superior outcomes for closing the abdominal separation gap compared to deep core stability exercises. This finding suggests Pilates may offer advantages beyond isolated transversus abdominis training, though the specific mechanisms underlying this superiority require further investigation.

A recent network meta-analysis by Yang et al. [32] compared 11 rehabilitation therapies for diastasis recti abdominis, including Pilates, suspension training, electro-acupuncture, core stability exercises, abdominal supports, abdominal and pelvic floor muscle exercise, isometric-isotonic exercises, and neuromuscular electrical stimulation. The analysis examined randomized controlled trials published through April 2024, providing comparative effectiveness data across multiple intervention modalities. While specific ranking data varied by outcome measure, the analysis confirmed that Pilates represents an evidence-based option within the spectrum of available DRA rehabilitation approaches [32].

The mechanisms underlying DRA reduction through exercise remain incompletely understood. Mechanistic research has identified a biomechanical paradox: while curl-up exercises narrow IRD by contracting the rectus abdominis toward the midline, isolated transversus abdominis (TrA) contractions may paradoxically widen IRD acutely due to the muscle's lateral-to-medial fiber orientation [33]. This finding challenges the traditional emphasis on isolated TrA training for DRA management. However, the same research demonstrates that TrA pre-activation during curl-ups, while maintaining or slightly widening the IRD, significantly reduces linea alba distortion—a measure of fascial slackening that may be more functionally relevant than gap width alone [33].

This biomechanical insight may explain why comprehensive Pilates protocols demonstrate superior outcomes compared to isolated deep core approaches. Pilates integrates multiple elements simultaneously: coordinated breathing with diaphragmatic descent and pelvic floor lengthening on inhalation, TrA and pelvic floor co-contraction during exhalation, spinal articulation through multiple planes (flexion, rotation, lateral flexion), and progressive loading across functional movement patterns [34]. Rather than targeting individual muscles in isolation, this integrated approach trains the "core canister" as a unified system—with the pelvic floor forming the base, diaphragm the roof, transversus abdominis the front wall, and multifidus the

posterior wall, all interconnected through thoracolumbar fascia [35]. The synergistic activation of the entire abdominal wall musculature within functional contexts, rather than selective TrA recruitment, may optimize linea alba tensioning while simultaneously improving force transfer across the midline and supporting lumbopelvic stability [33].

Effective Pilates protocols for DRA share common characteristics across studies. Mat-based exercises with progressive intensity over the intervention period have been shown to be the most effective [30]. Key exercises consistently include pelvic curls, single-leg lifts, chest lift variations, supine spine twist, bridge progressions and side-lying work—all emphasizing breath coordination with movement and maintenance of neutral spine positioning during execution [10,30]. Postpartum protocols typically begin with gentle pelvic tilts, breathing exercises, and modified bridge work before progressing to more challenging variations incorporating rotation and single-leg challenges. Exercises that cause visible abdominal "doming" or coning should be avoided as they indicate excessive intra-abdominal pressure that may strain the linea alba and prevent healing [29].

During pregnancy, Pilates protocols require specific modifications including avoidance of supine positioning after 16 weeks gestation, emphasis on pelvic floor lengthening during inhalation to prepare for delivery, and progressive reduction of intensity in the third trimester [36]. For prenatal intervention, studies have successfully implemented Pilates programs beginning between 20-32 weeks of gestation, with most protocols initiating between weeks 26-28 and continuing until delivery [17,20]. Program duration during pregnancy typically ranges from 4-8 weeks, with twice-weekly sessions of 35-50 minutes demonstrating effectiveness. The second and early third trimesters appear to represent an optimal window when women have typically passed first-trimester fatigue and nausea but retain sufficient mobility and comfort to engage in floor-based exercise [23].

Although the timing of postpartum Pilates initiation varies across studies and clinical guidelines, natural resolution of DRA occurs primarily during the first 8 weeks postpartum, after which spontaneous recovery plateaus [8]. This temporal pattern suggests an optimal window for intervention beginning around 6-8 weeks postpartum, once initial tissue healing has occurred but before maladaptive movement patterns become established. However, studies have demonstrated effectiveness across various postpartum timeframes from as early as 2 months to as late as 12 months postpartum [30,31], indicating potential benefits regardless of intervention timing. Most protocols recommend obtaining medical clearance before initiating

exercise, typically at the 6-week postpartum check-up for vaginal deliveries and 8-10 weeks following cesarean section [26].

Despite these promising findings, systematic reviews have rated the overall evidence quality as ‘very low’ to ‘low’ using GRADE criteria, primarily due to small sample sizes, methodological heterogeneity, and limited follow-up duration [29]. A comprehensive scoping review by Memon & Patel [37] examining diastasis recti abdominis rehabilitation in the postpartum period included 28 studies (14 clinical trials, 3 case series, and 11 observational studies) and noted considerable variability in diagnostic criteria and methods, DRA severity, time post-birth, and exercise program design. While DRA exercises focusing on deep and superficial muscles, pelvic floor muscles, respiratory maneuvers, functional exercises, or alternative interventions including Pilates showed promising results in reducing the inter-recti distance and related dysfunction, the heterogeneity in study design hinders generalizability of findings [37]. This underscores the need for larger, well-designed randomized controlled trials with standardized diagnostic criteria and longer follow-up duration to establish definitive clinical recommendations.

3.4 Effects of Pilates-Based Exercises on Pelvic Floor Function

Pelvic floor dysfunction represents a significant postpartum concern, with approximately 30-40% of women experiencing symptoms including urinary incontinence, pelvic organ prolapse, or sexual dysfunction following delivery [38]. Evidence suggests that Pilates-based exercise may offer benefits comparable to traditional pelvic floor muscle training (PFMT) while providing the additional advantage of integrated whole-body conditioning.

The landmark randomized controlled trial by Culligan et al. [39] directly compared 12 weeks of biweekly Pilates instruction versus physical therapist-led PFMT in 62 women. Both interventions produced statistically equivalent improvements in perineometry-measured pelvic floor strength: the Pilates group improved from baseline 14.9 ± 12.5 cmH_2O by +6.2 ± 7.5 cmH_2O ($p=0.0002$), while the PFMT group improved from 12.5 ± 10.4 cmH_2O by +6.6 ± 7.4

cmH_2O ($p=0.0002$), with no significant between-group difference ($p=0.85$). These findings demonstrate that Pilates produces pelvic floor strengthening outcomes non-inferior to gold-standard PFMT interventions [39].

More recent evidence provides compelling support for prenatal Pilates affecting postpartum pelvic floor outcomes. Buran and Erim [40] conducted a single-blind randomized controlled trial of 126 women who received eight weeks of prenatal Pilates training (twice weekly, initiated at 28-30 gestational weeks) or standard care. Postpartum urinary incontinence severity, assessed using the Michigan Incontinence Severity Index (M-ISI), revealed dramatic between-group differences: stress urinary incontinence median scores were 0 (0-4) in the Pilates group versus 7 (4-11) in controls ($p<0.001$), urgency incontinence scores were 0 (0-5) versus 4 (0-7) ($p<0.001$), and total M-ISI scores were 1.5 (0-15) versus 18 (8-28) ($p<0.001$). Notably, the Pilates group also demonstrated higher vaginal birth rates (80.6% vs. 54.2%, $p=0.003$) and shorter labor duration (9h 46min vs. 15h 29min, $p<0.001$), suggesting broader obstetric benefits beyond pelvic floor outcomes [40].

Comparative effectiveness research in postpartum populations suggests potential advantages of integrated Pilates approaches. Wang and An [41] conducted a randomized controlled trial of 38 postpartum women with urinary incontinence, comparing three interventions: Kegel exercises alone (n=14), Internet-guided Kegel exercises (n=12), and Internet-guided Pilates (n=12) over 6 weeks. The Pilates group demonstrated the greatest improvements across multiple outcome measures. In the 1-hour pad test, the Pilates group improved from 40.33 ± 3.89g to 18.67 ± 3.55g, compared to 24.00 ± 3.94g in the Kegel-only group. Episodes of incontinence decreased to 2.08 ± 0.52 in the Pilates group versus 2.93 ± 0.62 in the Kegel-only group. These findings suggest that Pilates' integration of pelvic floor activation within functional movement contexts may offer advantages over the isolated contractions characteristic of traditional Kegel exercises, though the small sample size warrants cautious interpretation [41].

Additional comparative research by Gonzaga et al. [42] examined 40 postmenopausal women randomized to either PFMT or Pilates for 12 weeks (three sessions weekly). Both groups demonstrated significant intra-group improvements in pad test results, mean daily urinary loss, and quality of life as measured by the International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF). While both interventions proved effective, the finding that Pilates produced comparable outcomes to specialized PFMT suggests its utility as an

accessible alternative or adjunct therapy, particularly for women seeking comprehensive exercise benefits beyond isolated pelvic floor training [42].

The theoretical basis for Pilates-pelvic floor integration lies in the coordinated activation of the "core canister" system. During Pilates breathing cycles, the pelvic floor and transversus abdominis co-contract during exhalation while the diaphragm descends and pelvic floor lengthens during inhalation [2,35]. This rhythmic coordination pattern trains not only pelvic floor strength but also the timing and synergy essential for functional continence control during activities involving increased intra-abdominal pressure such as coughing, laughing, or lifting. Research has demonstrated that contraction of the pelvic floor muscles occurs during various abdominal maneuvers, suggesting functional co-activation patterns that Pilates exercise may enhance [1,2].

3.5 Critical Limitations from Systematic Reviews

Despite promising findings from individual trials, systematic review evidence presents a more nuanced picture. Lemos et al. [43] conducted a systematic review and meta-analysis examining the Pilates method's effect on pelvic floor muscle function in healthy women. Searching multiple databases from October to December 2016, they identified 4,434 articles but selected only two studies suitable for meta-analysis. Their analysis revealed no significant between-group difference in pelvic floor muscle function as measured by perineometry ($p=0.32$), leading to the conclusion that available evidence does not demonstrate modification of pelvic floor muscle function in healthy women practicing Pilates [43].

This apparent contradiction between individual RCT findings and systematic review conclusions may reflect several factors. First, heterogeneity in Pilates protocols exists, with some emphasizing explicit pelvic floor cueing while others rely on presumed automatic co-activation. Many Pilates instructors believe the method can produce significant improvement in pelvic floor muscle resistance, yet approximately 49% of women who can contract these muscles do not perform adequate contractions and cannot increase urethral closure pressure [44]. Without specific cueing and feedback, Pilates exercises may not consistently recruit pelvic floor muscles effectively in all participants.

Second, differences between symptomatic and asymptomatic populations may explain divergent findings. Pilates may be more effective for women with existing pelvic floor dysfunction than for primary prevention in healthy women, as those with dysfunction may

benefit more from neuromuscular re-education and functional training. Third, measurement challenges arise as perineometry captures only maximal voluntary contraction strength rather than functional coordination, endurance, or timing—parameters that may be more responsive to Pilates training than peak force production. Fourth, the limited number of high-quality studies available for meta-analysis restricts the strength of conclusions that can be drawn.

A more recent systematic review and meta-analysis by Woodley et al. [45] examining postpartum exercise interventions provided moderate certainty evidence that pelvic floor muscle training reduced odds of urinary incontinence by 37% in the first year postpartum (seven randomized controlled trials, n=1,487). However, the review noted that evidence for exercise interventions beyond traditional PFMT remained insufficient to draw definitive conclusions, with authors stating "there is a lack of research to support the association between postpartum exercise and pelvic floor disorder severity" for many outcomes [45]. The findings support inclusion of PFMT into postpartum care but highlight the need for additional research on integrated approaches like Pilates.

Jacomo et al. [46] conducted a systematic review specifically examining whether exercise regimens other than PFMT can increase pelvic muscle strength. Their analysis concluded that available evidence does not support the effectiveness of alternative exercise regimens in increasing pelvic floor muscle strength, reinforcing the position that PFMT remains the gold standard intervention. However, they acknowledged that alternative exercises may offer benefits for other aspects of pelvic floor function not captured by strength measurements alone [46].

These systematic review findings underscore important limitations in the current evidence base. While individual studies demonstrate promise, the aggregate evidence remains insufficient to establish Pilates as equivalent to PFMT for pelvic floor muscle strengthening, particularly in asymptomatic populations. However, Pilates may offer complementary benefits including improved functional integration, enhanced body awareness, and comprehensive musculoskeletal conditioning that traditional PFMT does not address. Future research should employ larger sample sizes, standardized Pilates protocols with explicit pelvic floor cueing, longer follow-up periods, and multidimensional outcome measures capturing not only muscle strength but also coordination, endurance, and functional performance during activities of daily living.

3.6 Effects of Pilates on Postural Dysfunction and Low Back Pain

Postpartum low back pain and lumbopelvic pain affect approximately 20-25% of women beyond the immediate recovery period, representing a significant burden on maternal well-being and functional capacity [13]. During pregnancy, biomechanical adaptations including anterior pelvic tilt, increased lumbar lordosis, and altered trunk muscle activation patterns develop to accommodate the shifting center of gravity and growing uterus [9]. These postural changes often persist into the postpartum period, contributing to ongoing pain and dysfunction if not addressed through appropriate rehabilitation [5].

Recent systematic review evidence demonstrates that Pilates significantly reduces pregnancy-related and postpartum lumbopelvic pain. The scoping review by Köse et al. [23] analyzing 21 studies found that Pilates significantly reduced pain intensity and improved functional disability scores when assessed using validated instruments such as the Oswestry Disability Index (ODI). Sonmezer et al. [24] demonstrated that clinical Pilates reduced lumbopelvic pain (LPP) and functional disability scores over an 8-week intervention supervised by a physiotherapist, with improvements maintained at follow-up assessments [23].

A systematic review and meta-analysis by Mendo & Jorge [47] specifically examining pain and quality of life outcomes found that Pilates lessened pain (5 studies; SMD 1.41, 95% CI, 0.54-2.28) and disability (5 studies; SMD 0.83, 95% CI, 0.15-1.50), and improved quality of life (2 studies; SMD 2.10, 95% CI, 0.34-3.86) compared to control groups in pregnant women. These effect sizes suggest clinically meaningful improvements across multiple domains [47].

The mechanisms underlying pain reduction through Pilates likely involve multiple pathways. First, Pilates addresses the postural adaptations that persist after delivery by emphasizing spinal articulation, neutral spine positioning, and postural awareness during functional movements [15]. Exercises targeting the deep stabilizing muscles—particularly the transversus abdominis and multifidus—help restore optimal load distribution across the lumbopelvic region and reduce compensatory strain on superficial muscles and passive structures [48].

Second, Pilates promotes coordinated activation of the entire “core canister” system, addressing the functional interdependence between the diaphragm, pelvic floor, transversus abdominis, and multifidus [35]. This integrated approach may be particularly relevant for postpartum women, as pregnancy-related changes affect all components of the core system

simultaneously. Research examining pelvic floor muscle training combined with other physical therapy interventions for low back pain found low certainty evidence for improving pain (standardized mean difference = -0.73, 95% CI [-1.10, -0.36]), reflecting clinically meaningful pain reduction [49].

Third, the breathing patterns emphasized in Pilates may contribute to pain reduction through multiple mechanisms including modulation of intra-abdominal pressure, improved oxygenation of tissues, and effects on the autonomic nervous system that influence pain perception [36]. The controlled, diaphragmatic breathing characteristic of Pilates practice has been associated with reduced muscle tension and improved relaxation, potentially breaking pain-tension cycles [15].

Fourth, progressive strengthening of the hip and lower extremity musculature through Pilates exercises may reduce compensatory loading patterns that contribute to lumbopelvic pain. Hip muscle weakness, particularly of the gluteal muscles, is common postpartum and can lead to altered biomechanics during functional activities such as lifting, carrying, and ambulation [3]. Studies have demonstrated that home-based tele-Pilates interventions improved hip muscle strength and reduced anterior pelvic tilt in pregnant women, with corresponding reductions in low back pain and improvements in sleep quality [50].

Effective Pilates protocols for lumbopelvic pain typically include exercises such as pelvic tilts to support lower back and posture, cat-cow stretches to relieve tension and improve spinal mobility, side-lying leg lifts to strengthen hips and glutes, kneeling arm and leg reaches to promote stability and balance, and gentle seated twists to release spinal tension [24,36]. These movements emphasize breath coordination, spinal articulation, and progressive loading while maintaining neutral alignment and avoiding positions that exacerbate pain.

Program parameters across successful studies typically include 8-12 weeks of intervention, with 2-3 sessions per week of 45-60 minutes duration. Both mat-based and equipment-based (reformer) Pilates have demonstrated effectiveness, though mat-based programs may be more accessible for most postpartum women [36]. Supervision by qualified instructors, particularly those with specialized training in prenatal and postnatal exercise, appears important for ensuring proper technique and appropriate progression [23].

Despite these encouraging findings, limitations exist in the current evidence base. A systematic review by Pereira et al. [51] comparing Pilates with no exercise or lumbar stabilization for patients with chronic low back pain found that while Pilates showed benefits,

evidence quality was limited by small sample sizes and methodological concerns. The review noted the need for larger, higher-quality trials to establish definitive recommendations [51]. Additionally, most studies have examined mixed populations or general chronic low back pain rather than specifically focusing on postpartum women, limiting direct applicability of findings to the postpartum population.

Future research should examine dose-response relationships to optimize program intensity and duration, compare Pilates with other evidence-based interventions such as specific stabilization exercises or manual therapy, investigate which components of Pilates (breathing, strengthening, flexibility, postural training) contribute most to pain reduction, and evaluate long-term outcomes including return to pre-pregnancy activity levels and prevention of chronic pain development. Understanding which postpartum women are most likely to benefit from Pilates versus alternative interventions would also inform clinical decision-making and resource allocation.

4. Discussion and Clinical Implications

The current evidence base suggests that Pilates-based exercise offers a comprehensive approach to perinatal musculoskeletal rehabilitation, with demonstrated benefits across multiple outcome domains. During pregnancy, Pilates interventions have shown protective effects against perineal trauma, reduced labor pain and duration, and improvements in pelvic floor muscle preparation for delivery. In the postpartum period, Pilates demonstrates effectiveness for reducing diastasis recti abdominis, improving pelvic floor function comparable to traditional PFMT, and alleviating lumbopelvic pain and postural dysfunction.

The theoretical framework supporting Pilates' effectiveness centers on its integrated approach to the core-pelvic floor system. Unlike interventions targeting isolated muscles or movement patterns, Pilates trains the coordinated function of the diaphragm, pelvic floor, transversus abdominis, and multifidus as an integrated unit [35]. This systems-based approach may be particularly appropriate for addressing the multifactorial nature of pregnancy-related and postpartum musculoskeletal changes, which affect posture, breathing patterns, abdominal wall integrity, and pelvic floor function simultaneously.

However, several important limitations temper enthusiasm for Pilates as a universal solution. Systematic reviews consistently identify issues with evidence quality, including small sample sizes, heterogeneous intervention protocols, variable instructor qualifications,

inconsistent outcome measurement, and limited long-term follow-up [29,37,43]. The contradiction between promising individual RCT findings and more conservative systematic review conclusions highlights the need for caution in clinical recommendations pending higher-quality evidence.

The finding that Pilates does not significantly increase pelvic floor muscle strength in healthy women [43] raises important questions about mechanisms of action. If Pilates does not strengthen the pelvic floor muscles through hypertrophy or increased contractile capacity, alternative explanations for clinical benefits must be considered. Possibilities include improved neuromuscular coordination and timing, enhanced proprioceptive awareness facilitating voluntary control, better integration of pelvic floor function within whole-body movement patterns, and psychological benefits including reduced anxiety and improved body image that may influence symptom reporting.

From a clinical perspective, several practical considerations emerge. First, Pilates appears safe when appropriately modified for pregnancy and postpartum stages, with no adverse events reported across reviewed studies. Key modifications include avoiding supine positioning after 16 weeks gestation, avoiding exercises that cause visible abdominal doming, emphasizing pelvic floor lengthening as well as contraction, and progressing intensity gradually based on individual tolerance and recovery.

Second, instructor qualifications and exercise cueing appear important for optimal outcomes. Studies employing instructors with specialized prenatal/postnatal training and explicit pelvic floor cueing tend to report more consistent benefits [39,40]. Women should be encouraged to seek instructors certified in prenatal and postnatal Pilates rather than attending general Pilates classes during the perinatal period.

Third, timing considerations suggest different optimal windows for different outcomes. For DRA prevention, exercise beginning in mid-pregnancy (20-28 weeks) continuing through delivery shows promise [27]. For birth outcomes and perineal protection, programs initiated by 26-30 weeks gestation provide sufficient duration to achieve neuromuscular adaptations [17,40]. For postpartum DRA treatment, intervention between 6-18 weeks postpartum may optimize the balance between allowing initial tissue healing and intervening before recovery plateaus [8,37].

Fourth, Pilates should be considered one option within a broader toolkit of evidence-based interventions rather than a replacement for traditional PFMT or physical therapy when specific impairments exist. The evidence supports Pilates as potentially equivalent to PFMT for

some outcomes, but not superior [39,42]. For women with significant pelvic floor dysfunction, specialist assessment and individualized PFMT may be necessary, with Pilates serving as an adjunct or maintenance strategy.

Finally, accessibility and sustainability factors favor Pilates in some contexts. Once learned, many Pilates exercises can be performed at home without equipment, potentially improving long-term adherence compared to clinic-based PFMT requiring ongoing appointments [41]. The whole-body conditioning benefits of Pilates may also provide additional motivation for continued practice beyond isolated pelvic floor or abdominal training. However, costs associated with specialized instruction and equipment may present barriers for some women, highlighting the need for accessible delivery models including group classes, online instruction, and community-based programs.

5. Conclusions

Pilates-based exercise demonstrates promise as a comprehensive intervention for musculoskeletal rehabilitation across the perinatal continuum. Current evidence supports its use for reducing perineal trauma and labor pain when performed during pregnancy, treating diastasis recti abdominis in the postpartum period, managing pelvic floor dysfunction with outcomes comparable to traditional PFMT, and alleviating lumbopelvic pain and postural dysfunction. The integrated approach characteristic of Pilates—combining breathing coordination, deep core activation, pelvic floor engagement, and postural training—provides theoretical advantages for addressing the multifactorial nature of pregnancy-related musculoskeletal changes.

However, significant limitations in evidence quality constrain clinical recommendations. Small sample sizes, heterogeneous protocols, limited follow-up, and contradictory findings between individual trials and systematic reviews necessitate cautious interpretation. Future research priorities should include large, adequately powered RCTs with standardized Pilates protocols, longer follow-up periods to assess sustained benefits, comparative effectiveness studies versus established interventions, investigation of optimal dosing, timing, and exercise selection, studies examining which populations benefit most from Pilates, and cost-effectiveness analyses to inform resource allocation.

Until higher-quality evidence emerges, Pilates can be recommended as a safe and potentially effective option for perinatal musculoskeletal rehabilitation, particularly for

motivated women seeking comprehensive exercise approaches. It should be delivered by appropriately qualified instructors with prenatal and postnatal specialization, modified appropriately for pregnancy stage and postpartum recovery status, and considered within an individualized treatment plan that may include traditional PFMT, physical therapy, or other evidence-based interventions as needed. Healthcare providers should counsel women that while Pilates shows promise across multiple outcome domains, definitive evidence establishing superiority over alternative approaches remains limited, and individual responses may vary.

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Methodology: DP ,ZC, KD ,NT,

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