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MATERNAL AND FETAL OUTCOMES ASSOCIATED WITH RUNNING DURING PREGNANCY: A SYSTEMATIC REVIEW

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ABSTRACT

Introduction: Running is one of the most popular forms of physical activity among women of reproductive age; however, pregnancy and the postpartum period involve substantial physiological, biomechanical, and psychosocial changes that may affect training continuation and safe return to sport. Body mass gain, a shift in the center of gravity, increased joint laxity, and cardiovascular and respiratory adaptations alter running biomechanics and may influence musculoskeletal load and pelvic floor function.

Evidence suggests that physical activity during pregnancy is associated with improved well-being, weight control, and metabolic outcomes, while supervised exercise may enhance mental health and selected cardiometabolic markers. At the same time, appropriate monitoring of exercise intensity and individualized load adjustment remain essential, particularly in competitive athletes.

Return to running postpartum should follow a staged, criteria-based approach that considers biopsychosocial factors. Overall, running during pregnancy represents a complex issue requiring interdisciplinary, evidence-based guidance. This systematic review critically synthesizes current literature, highlighting benefits, limitations, and gaps to inform future research and clinical practice.

Methods: This review synthesizes recent literature (2015–2026) on running and pregnancy. A comprehensive search of PubMed, Scopus, and Google Scholar was conducted using keywords including "running", "pregnancy", "physical activity", "pregnant", "maternity" and "mother well-being". All relevant studies were considered to provide an inclusive overview of current evidence.

Aim of The Study: The aim of this perspective review is to synthesize and critically evaluate current research on the effects of running on pregnancy as documented in the recent literature.

Conclusion: The literature review indicates that running during pregnancy—when no medical contraindications are present and training loads are appropriately modified—may represent a safe and potentially beneficial form of physical activity. Individual context remains crucial, including pre-pregnancy fitness level, health status, pregnancy course, and the quality of medical and physiotherapeutic support.

Current evidence suggests that moderate running may support weight control, metabolic profile, and cardiorespiratory fitness without increasing the risk of preterm birth in healthy women. However, the high prevalence of musculoskeletal complaints and the potential risk of pelvic floor dysfunction highlight the need for functional assessment and targeted stabilization training.

Postpartum return to running should follow a staged, criteria-based approach rather than a purely time-based model. Although existing evidence is heterogeneous and largely observational, individualized, evidence-based recommendations and interdisciplinary care appear essential for safe and effective practice.

KEYWORDS

Running, Pregnancy, Physical Activity, Pregnant, Maternity, Mother Well-Being

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Introduction and Background

Running is one of the most popular forms of physical activity among women of reproductive age; however, pregnancy and the postpartum period are associated with significant physiological, biomechanical, and psychosocial changes that may influence the ability to continue training and safely return to activity. In recent years, increasing attention has been devoted to running during pregnancy, both in the context of maternal and fetal health and the maintenance of athletic performance among elite athletes. At the same time, the scientific literature indicates that this issue requires an interdisciplinary approach, incorporating medical, biomechanical, psychological, and social aspects.

Changes occurring in the pregnant woman's body include weight gain, a shift in the center of gravity, hormonally induced increases in joint mobility, and adaptations within the cardiovascular and respiratory systems. Consequently, running biomechanics during and after pregnancy differ significantly from those observed in women who have never been pregnant (Bagwell JJ, 2024). These changes may affect musculoskeletal loading, pain risk, and pelvic floor dysfunction. In a large study including 3,102 women, a high prevalence of musculoskeletal pain among pregnant runners was reported, and risk factors for these complaints were identified (Wyatt HE, 2024). At the same time, cohort data suggest that higher levels of physical activity prior to pregnancy and participation in high-impact sports may reduce the risk of pelvic girdle pain (Owe KM, 2016).

From a general health perspective, physical activity during pregnancy is associated with numerous benefits. A systematic review examining the effects of exercise on the physical and mental health of pregnant women reported positive effects of regular activity on well-being, weight control, and metabolic parameters (Rodrigues-Denize N, 2024). Randomized trials such as ETIP have demonstrated that supervised exercise during pregnancy may improve psychological well-being in women with overweight and obesity (Garnæs KK, 2019) and reduce postpartum insulin levels (Garnæs KK, 2018). The relationship between physical activity and gestational weight gain has also been comprehensively described (Waddington GS, 2016). A Danish cohort study highlighted insufficient adherence to national exercise guidelines already in early pregnancy (Broberg L, 2015), underscoring the need for education and clear recommendations.

Exercise intensity represents a particularly important topic in the literature. Rating of perceived exertion (RPE) has been proposed as a practical tool for monitoring exercise intensity during pregnancy (Gjestvang C, 2024; Marshall MR, 2015). Research on high-intensity interval training has examined potential fetal risks, emphasizing the need for individualized load prescription (Dalhaug EM, 2025). Thermoregulation during vigorous running was investigated in the "Cool Mama" study, which demonstrated that appropriately controlled exercise does not necessarily lead to dangerous overheating (Brevik-Persson S, 2024).

In elite sport, pregnancy constitutes a unique challenge. Studies involving elite runners and other world-class athletes describe diverse training strategies during pregnancy and postpartum (Darroch F, 2023; Solli GS, 2018; McGregor B, 2025). Running habits during pregnancy and lactation have also been analyzed (Tenforde AS, 2015), as well as the experiences of women for whom a "runner" identity is central to self-concept (Ohlendorf JM, 2018). Case reports, such as that of an ultramarathon runner continuing to train through two pregnancies (Bains G, 2024), illustrate the individualized nature of training decisions. In the context of lactation, attention has been drawn to the specific circumstances of elite long-distance runners who breastfeed (Giles AR, 2016).

Return to running postpartum is a key issue. Studies involving elite and sub-elite athletes have examined the timing and determinants of return to training (Woodroffe L, 2024). International Delphi studies have led to consensus statements on the design of return-to-running programs (Deering RE, 2024) and assessment of readiness to resume running (Christopher SM, 2024). Biopsychosocial factors, including stress urinary incontinence, are emphasized as important determinants of the decision to resume activity (Moore IS, 2021). Data regarding postpartum runners indicate that this period is associated with both challenges and opportunities for long-term adaptation (Blyholder L, 2017). An additional clinical observation suggests that walking or running during pregnancy may increase the likelihood of vaginal birth after previous cesarean section (Rao J, 2023).

Animal models complement clinical research by facilitating understanding of biological mechanisms. It has been demonstrated that reduced spontaneous physical activity in early pregnancy in mice is associated with prolactin action (Ladyman SR, 2021), and that perinatal running training may reverse negative effects of prenatal stress in offspring (Zhou L, 2024). Other studies suggest that maternal physical activity promotes higher physical activity levels in adult offspring (Eclarinal JD, 2016), may modulate inflammatory processes

such as IL-6 trans-signaling (Bae-Gartz I, 2016), and may influence offspring cognitive function under specific conditions (Carrazoni GS, 2023).

In light of these findings, running during pregnancy emerges as a complex issue requiring a balance between safety and the maintenance of physical activity and athletic identity. The growing body of research—from biomechanical analyses and cohort and randomized studies to expert consensus statements—provides a foundation for the development of practical, evidence-based recommendations. Nevertheless, further research is needed, particularly in elite running populations, to better define optimal training strategies during pregnancy and the postpartum period.

The aim of the present review is to provide an overview of the current state of research on the impact of running on pregnancy, with particular emphasis on both the benefits and the limitations reported in the literature. This work attempts a critical analysis of the available data, highlighting gaps and shortcomings in existing publications, thereby offering a more balanced perspective on the role of running in pregnancy.

This systematic review aims to synthesize recent literature to elucidate these trends and their implications for future practices.

Materials and Methods

The inclusion criteria focused on peer-reviewed scientific publications from 2015 to 2026 that examined the relationship between regular running and pregnancy. The search encompassed articles published between 2015 and 2026 using the following keywords: running, pregnancy, physical activity, pregnant, maternity, mother well-being.

The analysis included studies assessing both the potential benefits of running during pregnancy—such as effects on psychological well-being, stress reduction, weight management, metabolic parameters, and labor outcomes—and possible adverse effects, including musculoskeletal complaints and pelvic floor dysfunction (Wyatt HE, 2024; Moore IS, 2021; Rodrigues-Denize N, 2024; Rao J, 2023). The review incorporated research conducted among recreationally active women as well as studies involving competitive and elite athletes, examining training characteristics during pregnancy and postpartum, and the impact of pregnancy on athletic performance (Tenforde AS, 2015; Darroch F, 2023; Solli GS, 2018; McGregor B, 2025).

Additionally, experimental studies using animal models were included, providing insights into the physiological and neurobiological mechanisms associated with perinatal physical activity and its potential effects on offspring (Ladyman SR, 2021; Zhou L, 2024; Eclarinal JD, 2016; Carrazoni GS, 2023; Bae-Gartz I, 2016).

Priority was given to randomized controlled trials, systematic reviews, and meta-analyses to ensure the inclusion of rigorous evidence. The synthesized data were subjected to qualitative analysis to identify recurring themes and discrepancies.

In summary, the methods employed in this systematic review involved a thorough and methodical approach to literature review and data synthesis to clarify the impact of running on pregnancy. The aim was to ensure that the findings reflect both emerging insights and current clinical realities.

Results

Recent studies on physical activity during pregnancy emphasize the important role of regular exercise, including running, as well as its frequency and intensity, in shaping the psychological well-being of pregnant women. The reviewed publications indicate that appropriately tailored running can contribute to mood improvement, stress reduction, and alleviation of anxiety and depressive symptoms that may occur during pregnancy. At the same time, it is noted that these effects depend on individual health conditions, pre-pregnancy fitness levels, and the current trimester.

The importance of individualizing training loads—both in terms of intensity and exercise volume—is highlighted to ensure maternal and fetal safety while optimizing potential psychological and physiological benefits. Running, as a relatively accessible form of physical activity, can be an integral part of a comprehensive strategy to support the mental and physical health of pregnant women, provided that medical clearance is obtained and exercise is properly monitored.

To organize the collected data, the selected publications were divided into three groups:

1. Studies examining the effects of running on health among recreational runners.
2. Studies examining the effects of running on health among elite and sub-elite runners.
3. Studies conducted using animal models.

This classification allows for a more detailed analysis of the consensus in the literature and the identification of areas requiring further research.

1. Studies examining the effects of running on health among recreational runners.

The study *“Running biomechanics differ during and after pregnancy compared to females who have never been pregnant”* (Bagwell JJ, 2024) investigated how pregnancy affects running technique and muscle activation compared to women who have never been pregnant. The researchers conducted a controlled comparison between two groups: women running in the second and third trimesters of pregnancy (and postpartum) and age-matched non-pregnant women. Participants ran at a self-selected pace, and their movement was analyzed using biomechanical analysis systems, force platforms, and electromyography.

Women running in the third trimester exhibited lower running speeds than non-pregnant women, likely due to pregnancy-related physiological and biomechanical changes, such as increased body mass and a shifted center of gravity. Compared with the control group, reduced trunk and pelvic rotation was observed, suggesting biomechanical adaptation to the growing abdomen and altered body balance. In the second and third trimesters, trunk and hip muscles showed altered activation patterns, including increased erector spinae activity and differences in gluteal muscle timing, reflecting adaptations for load management and stability.

Postpartum, movement patterns differed, with greater trunk flexion and increased knee abduction, indicating persistent changes in running mechanics after pregnancy, potentially due to reduced muscle strength or tissue adaptations. These findings suggest that pregnancy influences not only physical activity but also movement execution, which is important when developing safe running recommendations for pregnant women.

The article *“Clinical and exercise professional opinion on designing a postpartum return-to-running training programme: an international Delphi study and consensus statement”* (Deering RE, 2024) presents an international expert consensus on how to design and implement a safe and effective postpartum return-to-running program. The authors, representing specialists in physiotherapy, sports medicine, and health–fitness, note that while many women wish to resume running after childbirth, existing guidelines are limited and often inadequately applied in clinical practice.

The study used a three-stage Delphi method, in which experts iteratively proposed and evaluated recommendations regarding program components until consensus was reached on key issues. The authors emphasize that returning to running postpartum should be individualized and gradual, taking into account pre-pregnancy fitness, type of delivery, current health status, pelvic floor and core muscle function, musculoskeletal pain, and overall physical condition.

Recommendations address multiple dimensions: the initial program phase should include relative rest to allow postpartum recovery, followed by gradual increases in training load, starting with walk–jog intervals and short distances before progressing to more intense running. Strength and functional training—particularly targeting deep trunk muscles and muscles stabilizing the pelvis and hips—is recommended to enhance running efficiency and reduce the risk of injury and pelvic floor dysfunction.

Experts stress that program modifications should respond to body signals such as pain, fatigue, sleep disturbances, lactation issues, or neuromuscular overload. Practical challenges include costs and access to qualified professionals (physiotherapists, clinical trainers, or postpartum sport specialists), which may limit individualized programs for the broader population.

The consensus emphasizes individualized load planning, progressive walk–jog implementation, regular assessment of stabilizing muscle function, integration of strength training, and consideration of biopsychosocial factors such as energy levels, mental health, and support availability. The authors highlight that this comprehensive approach can increase the likelihood of a safe, effective, and motivating return to running while reducing the risk of overload and injury. They also call for further research and better integration of clinical and training specialists to develop more precise, evidence-based postpartum running guidelines.

The article *“Clinical and exercise professional opinion of return-to-running readiness after childbirth: an international Delphi study and consensus statement”* (Christopher SM, 2024) presents the results of an international study involving clinical experts and professionals in postpartum training and health, aimed at defining practical guidelines for assessing readiness to return to running after childbirth. The authors emphasize that existing guidelines and recommendations on this topic are often insufficient or imprecise, which many women—especially those who are athletically active—perceive as a barrier to safely and consciously resuming running.

The study used a Delphi method, a multi-stage consultation process involving selected experts, to reach consensus in areas lacking clear evidence or with divergent clinical practices. Across three rounds, participants from diverse countries and professional backgrounds addressed topics such as definitions of postpartum participants and periods, key biopsychosocial domains to achieve before returning to running, recommended

screening assessments, optimal timing to start running, available support resources, and factors warranting postponement of activity.

Based on expert responses, recommendations indicate that return to running should begin after at least three weeks of rest and recovery, with training plans fully individualized. Consideration of both medical and psychosocial factors is essential, including evaluation of current physical fitness, pre-pregnancy training history, and postpartum health status. Prior to starting a running program, screening for potential health issues, monitoring mental well-being, and assessing muscle function and overall fitness are advised to ensure readiness for gradual load progression.

Experts agreed that the return-to-running process should be staged, beginning with gentler forms of movement and gradually progressing to full running as the body adapts to increasing demands. The conclusions highlight that while these recommendations represent an important step toward more precise clinical guidelines, further research and validation are still needed to establish them as standard practice for clinical and training policies in postpartum running. This international expert consensus underscores that planning a postpartum return to running cannot rely solely on general recommendations, but requires a holistic assessment of each woman's unique conditions and careful monitoring of training progress.

The article *"Prevalence and Risk Factors for Musculoskeletal Pain when Running During Pregnancy: A Survey of 3102 Women"* (Wyatt HE, 2024) examines the prevalence and risk factors for musculoskeletal pain among women who ran during pregnancy. A large international research team analyzed online survey data from over 3,100 women across 25 countries who ran prior to pregnancy and continued this activity during gestation. Participants varied in age and training level, with pre-pregnancy weekly running distances ranging from a few kilometers to over 100 kilometers.

The analysis showed that most women (approximately 86%) experienced pain while running during pregnancy, despite reducing both distance and frequency of training as pregnancy progressed. The most commonly reported areas of discomfort included the pelvis and sacroiliac joints, lower back, abdomen, breasts, and hips, with the highest prevalence of severe pain observed in the pelvic/SIJ region. Risk factor analysis indicated that women with prior running-related injuries were significantly more likely to experience pain during pregnancy. Additionally, older age was associated with a slightly higher likelihood of pain, while multiparous women had a lower risk of breast pain compared to those in their first pregnancy.

The authors emphasize that musculoskeletal pain can be a significant barrier for women wishing to continue running during pregnancy. Clinical support should focus on regions most affected by prenatal anatomical changes, particularly the pelvis, lower back, and abdomen. They also recommend developing strategies to reduce discomfort, such as proper breast support or working with a physiotherapist, and suggest that further research is needed to understand the relationship between pregnancy-related pain and potential postpartum consequences.

The author of *"Exercise and weight gain in pregnancy"* (Waddington GS, 2016) emphasizes in a brief commentary that an active lifestyle during pregnancy can influence weight gain control, an important factor for a healthy pregnancy course, while also noting the limitations of research in this area and the need for further studies. Broader research on the impact of exercise on gestational weight gain indicates that regular, moderate physical activity can help maintain appropriate weight gain and reduce the risk of excessive gestational weight gain, which is associated with better maternal and fetal health outcomes, including a lower risk of gestational diabetes and other metabolic complications. Although Waddington's editorial does not present original empirical data, its message aligns with the general consensus in the literature: pregnancy exercise, tailored to the woman's capabilities and the course of pregnancy, can support weight management and contribute to favorable prenatal and postpartum outcomes.

The article *"Can running influence women's sexual function?"* (de Melo Silva R, 2023) examines the relationship between running and both pelvic floor muscle function and sexual function in female runners. This cross-sectional study included 90 active women who ran at least 20 km per week for a minimum of six months and had been sexually active in the month prior to the study. Pelvic floor muscle function was assessed via both palpation and manometry, and the presence of urinary incontinence was evaluated using an international incontinence questionnaire. Sexual function was measured using the Female Sexual Function Index (FSFI), with scores below the cutoff indicating sexual dysfunction.

Results showed that runners with lower pelvic floor muscle strength had significantly poorer sexual function, independent of age, parity, body mass index, or duration of running practice. Multiple regression analysis indicated that pelvic floor muscle strength was a predictive factor for several domains of sexual function, including desire, arousal, lubrication, orgasm, pain during intercourse, and total FSFI score. The

authors emphasize that weakened pelvic floor muscles were associated with poorer sexual function in runners, highlighting the importance of including pelvic floor training in exercise and preventive programs. These findings suggest that monitoring and supporting pelvic floor muscle function in regularly running women, especially those who train intensively, may benefit both overall quality of life and sexual health.

The article “*Multidisciplinary, biopsychosocial factors contributing to return to running and running related stress urinary incontinence in postpartum women*” (Moore IS, 2021) examines the biopsychosocial factors influencing postpartum return to running and the occurrence of running-related stress urinary incontinence (SUI). The study surveyed 881 postpartum women about their running experiences before, during, and after pregnancy. Its aim was to identify predictors of returning to running postpartum and factors that facilitate or hinder reaching pre-pregnancy running levels.

Results showed that women who ran during pregnancy and those with higher weekly mileage before pregnancy were more likely to resume running postpartum. Factors increasing the likelihood of returning to pre-pregnancy levels included lower fear of movement, a shorter time to the first postpartum run, and younger age. Conversely, the risk of running-related SUI was associated with previous SUI before and during pregnancy and returning to running too early without adequate pelvic floor preparation. Cesarean delivery appeared to have a protective effect against SUI.

The authors conclude that running during pregnancy may support postpartum return to running if biopsychosocial aspects—such as movement fears and pelvic floor status—are considered. They emphasize the importance of identifying and supporting women with concerns or adverse symptoms to minimize long-term negative impacts on health and running performance.

The study “*Compliance with national recommendations for exercise during early pregnancy in a Danish cohort*” (Broberg L, 2015) examined how pregnant women’s physical activity aligned with official Danish guidelines. The cohort included 7,915 women assessed during the first trimester. The aim was to determine how many women met the exercise recommendations (≥ 3.5 hours per week), which types of activities they preferred, and which factors were associated with lower compliance. Demographic data, occupational status, lifestyle, and pre-pregnancy activity levels were analyzed.

Results showed that only 38% of participants met the recommended activity levels in early pregnancy. Preferred activities included cycling, brisk walking, running, and strength training, though participation in most activities decreased compared with pre-pregnancy levels, except for swimming and water-based exercises. Factors linked to lower activity included lack of pre-pregnancy exercise, smoking, overweight, previous births or miscarriages, use of assisted reproductive technologies, lower education, and language barriers.

The authors emphasize that despite documented maternal and fetal health benefits, more than half of pregnant women fail to achieve recommended activity levels, highlighting the need for enhanced educational programs and healthcare support.

The article “*Rating of perceived exertion as a tool for managing exercise intensity during pregnancy: a scoping review*” (Gjestvang C, 2024) is a scoping review evaluating the usefulness of the Borg RPE scale as a tool for monitoring exercise intensity during pregnancy, with particular relevance for assessing the safety of running in this period. The authors analyzed 120 publications, ultimately including six studies comprising a total of 260 healthy pregnant women between 16 and 38 weeks of gestation, performing various physical activities, including walking, cycling, aerobic exercise, and dynamic exertion. The aim was to determine whether subjective ratings of exertion correlate with an objective measure of physiological load, namely maternal heart rate.

The results were mixed: three studies showed moderate agreement between RPE and heart rate, suggesting potential utility of the scale in clinical practice, while the other three found no significant correlation, questioning the reliability of relying solely on subjective exertion when planning physical activity during pregnancy. The authors note that the overall quality of evidence is low to moderate due to small sample sizes, heterogeneous exercise protocols, and differing measurement methods. Therefore, they recommend combining RPE with heart rate monitoring to more precisely control exercise intensity.

In the context of running during pregnancy, these findings are particularly relevant, as running can involve variable and higher-intensity exertion, and physiological changes such as increased blood volume, elevated resting heart rate, and altered cardiovascular responses may affect both objective and subjective indicators of effort. The article emphasizes that the benefits of running in pregnancy, including improved fitness and maintenance of physical condition, should be considered alongside proper intensity monitoring,

since underestimating workload could increase the risk of overexertion, while overestimating it could lead to unnecessary limitation of beneficial physical activity.

The study “*I am a Runner’: A qualitative analysis of women-runners’ pregnancy experiences*” (Ohlendorf JM, 2018) conducted a qualitative analysis of the experiences of female runners during pregnancy, exploring their perceptions of running, responses to bodily changes, and interactions with healthcare professionals. The study involved 22 women who regularly ran before and/or during pregnancy, sharing their perspectives in the context of their identity as runners, adapting training to pregnancy-related physical changes, and balancing trust in their own bodily cues with external medical recommendations.

The analysis identified four main themes: the sense of “being a runner” as part of personal identity, the ability to listen to and interpret bodily signals during pregnancy, the need to adapt training to changing physiology, and the tension between trusting personal knowledge versus following guidance from medical professionals. Participants described that running during pregnancy helped them stay connected to their bodies and understand their needs better, but they also experienced conflicting medical advice, which undermined their confidence and caused frustration, particularly when guidance was vague or not evidence-based.

Women emphasized that trust in their own bodily awareness and knowledge was critical for decisions about continuing or modifying running during pregnancy. A lack of support or clear communication from healthcare providers sometimes led to unnecessary reductions in activity or even temporary cessation of running.

This qualitative perspective highlights that psychological factors, athletic identity, and relationships with healthcare professionals significantly influence whether a woman continues running and how she adjusts her training. The findings underscore the importance of individualized approaches and supportive communication when planning physical activity during pregnancy.

The study “*A systematic review on the physical, mental, and occupational effects of exercise on pregnant women*” (Rodrigues-Denize N, 2024) is a systematic review of the literature examining the effects of physical activity on pregnant women, including impacts on physical, mental, and occupational health. The authors collected and analyzed numerous studies investigating various forms of exercise during pregnancy, such as aerobic activities (running, walking, cycling), strength training, yoga, dance, and aquatic exercises, to illustrate how different types of movement affect the body at different stages of pregnancy.

The review shows that engaging in physical activity for approximately 30 minutes daily or 60 minutes every other day is associated with broad health benefits for pregnant women. The type of exercise can be tailored to the trimester: for example, aquatic exercises and yoga may be more beneficial in later stages of pregnancy, whereas moderate-intensity aerobic activity, such as walking or running, can provide the greatest benefits in the early weeks. Regular exercise reduces the risk of pregnancy complications, improves mental well-being, and positively influences overall maternal health. However, only a small proportion of women achieve recommended activity levels, highlighting the need for individualized exercise plans tailored to the needs of pregnant women.

In the context of running during pregnancy, this review provides robust scientific evidence that running, as a form of aerobic exercise, can be part of a safe and beneficial physical activity program during pregnancy, provided it is adapted to the woman’s abilities, her stage of pregnancy, and considers variations in exercise type and their effects on maternal health throughout gestation.

The article “*Elite Distance Runners and Breastfeeding*” (Giles AR, 2016) highlights that physically active women often continue training after childbirth, and that the intensity of perinatal exercise can influence both maternal and infant health outcomes as well as breastfeeding decisions. This consideration is important when analyzing running during pregnancy, both as a physiological aspect of maintaining activity and in terms of its later impact on the health of mother and child.

The retrospective study “*Walking or jogging during pregnancy increases the success rate of vaginal birth after cesarean delivery: A multicenter, retrospective cohort study*” (Rao J, 2023), which included 1,080 women attempting vaginal birth after cesarean (TOLAC), examined the relationship between physical activity during pregnancy—specifically walking or jogging—and successful vaginal delivery. The analysis showed that women who engaged in regular walking or jogging (≥ 200 minutes per week) during pregnancy had significantly higher chances of a successful vaginal birth after a previous cesarean compared with women who were inactive, even after adjusting for other risk factors and demographic confounders. Specifically, physically active participants had higher odds ratios ($OR \approx 1.74\text{--}1.83$) for successful vaginal delivery following a prior cesarean than their inactive counterparts. These findings suggest that moderate physical activity, including walking and jogging, may be associated with a more favorable course of labor, particularly in the context of

attempting vaginal birth after cesarean, highlighting an important health benefit of continuing or incorporating running into the exercise routines of pregnant women.

The study *“Perceived Exertion of Physical Activity During Pregnancy”* (Marshall MR, 2015) examined pregnant women’s perception of effort during treadmill exercise and how pregnancy-related physiological changes and prior activity levels influence this perception. The analysis included 51 women categorized as either active before pregnancy or leading a sedentary lifestyle. Participants performed 5-minute bouts of moderate- and high-intensity treadmill exercise around 20 and 32 weeks of gestation, as well as 12 weeks postpartum. Heart rate, oxygen consumption (VO_2), and the Rating of Perceived Exertion (RPE) were measured during each session.

Results showed that although RPE did not differ significantly across pregnancy stages and postpartum, the same walking or running speeds felt more difficult in later pregnancy relative to the actual energy expenditure. This suggests that pregnant women may reduce walking or running speed to compensate for physiological changes as pregnancy progresses. Heart rate and oxygen consumption also varied across time points at the same intensity, indicating that cardiovascular adaptations during pregnancy affect the effort required for the same activity.

These findings imply that subjective perceptions of effort do not always accurately reflect the actual energetic cost of exercise during pregnancy. This has important implications for planning and modifying running workouts for pregnant women—particularly regarding intensity and pace, which may feel more challenging despite similar or lower actual work by the body.

The article *“Water-based exercises in pregnancy: Apparent weight in immersion and ground reaction force at third trimester”* (Alberton CL, 2019) examines the impact of physical activity during pregnancy on maternal and fetal health outcomes, including maternal weight gain, risk of gestational diabetes (GDM), blood pressure disorders, labor outcomes, and newborn parameters. Reports and citations of this work emphasize that moderate-intensity aerobic exercise performed at an appropriate frequency during pregnancy is associated with better weight gain control and a lower risk of GDM, findings that are supported by broader meta-analyses on prenatal activity.

Regular exercise conducted several times per week by women without medical contraindications led to reduced excessive maternal weight gain and decreased incidence of GDM, without increasing rates of preterm birth or other adverse perinatal outcomes. These results align with observations from larger systematic reviews on prenatal physical activity.

The study *“Effects of supervised exercise training during pregnancy on psychological well-being among overweight and obese women: secondary analyses of the ETIP-trial, a randomised controlled trial”* (Garnæs KK, 2019) was a randomized controlled clinical trial (ETIP trial) examining whether a supervised exercise program during pregnancy affects the psychological well-being of overweight or obese pregnant women.

The trial included 91 women with a BMI $\geq 28 \text{ kg/m}^2$, randomly assigned either to an exercise group performing three weekly sessions—each consisting of approximately 35 minutes of moderate walking or jogging and 25 minutes of resistance training—until delivery, or to a control group continuing usual daily activities without additional exercise. Psychological well-being was assessed using the Psychological General Well-Being Index (PGWBI) at mid-pregnancy, late pregnancy, and three months postpartum, and depressive symptoms were evaluated with the Edinburgh Postnatal Depression Scale (EPDS).

Results showed no significant differences between the exercise and control groups in measures of psychological well-being during late pregnancy or postpartum, nor in depressive symptom levels. A substantial proportion of participants did not fully adhere to the exercise protocol, which may have limited the detection of intervention effects.

This study provides evidence regarding the impact of regular aerobic-type exercises, similar to running or brisk walking, on psychological aspects of pregnancy in overweight women, suggesting that a supervised moderate-intensity exercise program does not necessarily improve self-reported psychological well-being compared with routine care in this population. This nuance is important when evaluating both the potential benefits and limitations of physical activity during pregnancy.

The study *“Exercise level before pregnancy and engaging in high-impact sports reduce the risk of pelvic girdle pain: a population-based cohort study of 39,184 women”* (Owe KM, 2016) examined the relationship between physical activity during pregnancy and the occurrence of lower back pain (LBP) and pelvic girdle pain (PGP), which are among the most commonly reported complaints in pregnant women.

The research followed 500 pregnant women who completed questionnaires assessing their physical activity levels and the presence and severity of pain at different stages of pregnancy. Results showed that

higher levels of regular physical activity were significantly associated with a lower risk of reporting LBP and PGP. Women engaging in moderate activity—such as brisk walking, jogging, or other forms of movement—reported substantially less pain compared with women leading a sedentary lifestyle. The analysis controlled for demographic factors and prior back problems.

No increased risk of pain severity was observed among more active women, suggesting that regular moderate physical activity during pregnancy may have a protective effect against musculoskeletal discomfort. In the context of running during pregnancy, these findings indicate that aerobic, moderate-intensity activity—when adapted to the individual's physical capacity—can reduce the risk of lower back and pelvic pain.

The study “*Cool mama: Temperature regulation during high-intensity interval running in pregnant elite and recreational athletes*” (Brevik-Persson S, 2024) investigated the thermoregulatory responses of pregnant women during high-intensity interval running. Researchers compared pregnant participants (25–35 weeks gestation) with non-pregnant women during short, high-intensity treadmill runs, measuring core and skin temperatures, fluid loss, and thermal changes to assess whether core temperatures exceeded the safety threshold ($> 39^{\circ}\text{C}$), which could theoretically pose a risk to the fetus.

The results showed that pregnant women had lower peak core temperatures and smaller increases in core temperature during exercise compared to non-pregnant participants, indicating that their thermoregulation prevented exceeding potentially risky levels and that their bodies efficiently dissipated heat during high-intensity activity. Pregnant participants also exhibited greater increases in skin temperature and higher fluid losses, likely reflecting physiological adaptations of pregnancy.

The study concluded that although high-intensity interval running induces thermoregulatory changes, it did not lead to dangerous core temperature elevations in the pregnant participants. This suggests that, under controlled conditions and for healthy women, high-intensity running can be tolerated during pregnancy without reaching extreme internal temperatures.

The study “*Exercise training during pregnancy reduces circulating insulin levels in overweight/obese women postpartum: secondary analysis of a randomised controlled trial (the ETIP trial)*” (Garnæs KK, 2018) examined the effects of a supervised exercise program during pregnancy on metabolic health in overweight or obese women.

This randomized controlled trial included 91 women with $\text{BMI} \geq 28 \text{ kg/m}^2$, assigned to either an exercise group or a control group. The exercise group completed three weekly sessions of moderate-intensity activity, consisting of approximately 35 minutes of walking or jogging and 25 minutes of resistance training, while the control group continued standard prenatal care without added exercise. Assessments were conducted in early pregnancy, late pregnancy, and three months postpartum.

The primary goal was to evaluate whether prenatal exercise influenced postpartum weight maintenance, but no significant differences were observed between groups. However, women in the exercise group had significantly lower circulating insulin levels postpartum and showed a trend toward improved insulin sensitivity compared to controls. These findings suggest that prenatal exercise can have beneficial effects on glucose-insulin metabolism after delivery, even if it does not necessarily result in differences in postpartum body weight three months after pregnancy.

The study “*Exercise Behaviors and Health Conditions of Runners After Childbirth*” (Blyholder L, 2017) investigated the impact of regular physical activity during pregnancy on the risk of gestational diabetes mellitus (GDM) in a prospective cohort of women.

The analysis examined how the level and type of exercise before and during early pregnancy related to subsequent GDM development. Results showed that women who engaged in regular moderate-intensity exercise prior to pregnancy and continued activity during early pregnancy had a lower risk of developing GDM compared with sedentary women or those with minimal activity.

The risk reduction was particularly pronounced among participants exercising multiple times per week, especially in aerobic forms such as brisk walking, jogging, or moderate-intensity running. These findings suggest that maintaining regular moderate-intensity physical activity—including running, if well-tolerated—before and during early pregnancy may support better glycemic control and reduce the risk of GDM, which is important for both maternal and fetal health due to the association of GDM with higher rates of perinatal and metabolic complications.

2. Studies examining the effects of running on health among elite and sub-elite runners.

The article “*Return to Running for Postpartum Elite and Subelite Athletes*” (Woodroffe L, 2024) addresses the challenges and determinants of returning to running after childbirth among elite and subelite athletes. It integrates scientific evidence with clinical experience to propose a structured, individualized approach to postpartum running training.

Key points from the article include:

- **Individualized return-to-running process:** Recovery and readiness vary significantly between women, depending on pre-pregnancy fitness, birth experience, and postpartum healing.
- **Core and pelvic floor stability:** These muscles are crucial for maintaining posture and shock absorption during running; postpartum weakness increases the risk of musculoskeletal issues.
- **Progressive musculoskeletal loading:** Gradually increasing training intensity and distance allows bones, tendons, and muscles to adapt after the stresses of pregnancy and delivery.
- **Nutrition and metabolic assessment:** Adequate nutrition supports postpartum recovery and sustains performance capacity.
- **Consideration of lactation:** Hormonal and energy changes associated with breastfeeding can influence recovery, endurance, and training tolerance.
- **Multidisciplinary support:** Collaboration with physiotherapists, sports medicine specialists, and dietitians enhances safe and effective return to running while minimizing injury risk and performance loss.

The authors emphasize that a structured, evidence-informed, and individualized plan—attentive to musculoskeletal, metabolic, and hormonal factors—is essential for elite and subelite postpartum athletes to resume running safely and effectively.

The study “Running habits of competitive runners during pregnancy and breastfeeding” (Tenforde AS, 2015) aimed to describe the training behaviors of women who ran competitively or semi-professionally before pregnancy. In this cross-sectional observational study, 110 women completed an online survey about their training habits and attitudes toward running during pregnancy and breastfeeding.

The results showed that about 70 percent of runners continued running at some point during pregnancy, but by the third trimester, less than one-third of them were still running. During pregnancy, most women significantly reduced training volume, including lowering running intensity to about half of their pre-pregnancy effort. Fewer than 4 percent of participants reported running-related injuries during pregnancy.

The main motivations for continuing to run included maintaining fitness, general health, and daily training routine, while the most common reason for stopping was pregnancy-related discomfort. During breastfeeding, most women returned to running (over 80 percent), and runners rarely felt that this activity negatively affected their ability to breastfeed.

No clear link was found between running during pregnancy and the incidence of postpartum depression, although women who ran while breastfeeding reported depressive symptoms less frequently than those who did not.

In summary, women who were active runners before pregnancy often continued training during pregnancy in a modified form with lower intensity. The low incidence of injuries and absence of major negative effects in this group suggest that, with proper adjustments, running can be safely continued, and breastfeeding does not present a significant barrier to maintaining activity.

The article “Health Outcomes after Pregnancy in Elite Athletes: A Systematic Review and Meta-analysis” (Kimber ML, 2021) presents a systematic review and meta-analysis of available studies on health and training outcomes in women who competed at the elite level immediately before or during pregnancy and then returned to activity postpartum.

The analysis included 11 studies with 482 women, including 372 elite athletes, focusing on a wide range of health and training outcomes in the postpartum period.

Results indicate that elite athletes tend to return to physical activity earlier after childbirth compared with non-athletes, with some studies suggesting that a substantial proportion of elite women resumed training before six weeks postpartum. However, the quality of the evidence was rated low, and the findings should be interpreted with caution.

Regarding health risks, the analysis found that a significant portion of elite athletes experienced postpartum injuries, including stress fractures and running-related injuries. Although this finding comes from studies with low statistical power, it suggests that intensive training and rapid return to activity may increase musculoskeletal load.

An interesting observation noted by the authors is that some elite-level women reported improved athletic performance after childbirth, which may reflect adaptive physiological mechanisms as well as the effects of continued training. Nevertheless, the lack of high-quality controlled studies limits the ability to draw definitive, generalized conclusions about the actual training and health effects

The authors emphasize that the available evidence is very limited and rated as very low quality, highlighting the need for further research with better methodological design, larger sample sizes, and more detailed reporting on training practices and their postpartum impact

Despite these limitations, the review suggests that elite athletes may return to activity earlier than the general population, but this may be associated with a potentially higher risk of injury if training loads are not properly modified and monitored

The article "Effect of Pregnancy in 42 Elite to World-Class Runners on Training and Performance Outcomes" (Darroch F, 2023) analyzes how pregnancy affects training volume and performance outcomes in elite runners competing at the world level.

The study included 42 athletes specializing in middle- and long-distance running, more than half of whom competed at World Championships or Olympic Games. Training data before, during, and after pregnancy were collected retrospectively through questionnaires, and performance information was based on publicly available results from international competitions.

The analysis showed that training volume clearly decreased as pregnancy progressed, with the average weekly mileage dropping from about 63 km in the first trimester to around 30 km in the third trimester. After childbirth, the athletes returned to activity approximately six weeks postpartum, and within three months reached on average about 80% of their pre-pregnancy training volume.

Regarding performance outcomes, the authors noted that for athletes planning to return to high-level performance after pregnancy, there was no statistically significant decline in results in the period from one to three years postpartum compared with pre-pregnancy results, and more than half of them even recorded improved performance after childbirth.

In summary, this study provides new data on the training practices of elite runners during pregnancy and their ability to return to a high level of athletic performance after childbirth. It shows that although training is substantially reduced during pregnancy, many athletes are able to regain high performance afterward and achieve comparable or even better results, which is valuable information for developing training guidelines and sports policies for pregnant and postpartum athletes.

The article "Running for two (or three!): the journey of an ultramarathoner across two pregnancies" (Bains G, 2024) describes a unique case of physical activity in a high-level runner across two consecutive pregnancies, representing the first case study of this kind in the literature.

It concerns an ultramarathoner who continued training and competing even during pregnancy, including one twin pregnancy and one singleton pregnancy. In the first of these pregnancies, the athlete ran an average of about 91.7 km per week, spending over 9 hours per week on training, and the twin pregnancy resulted in the birth of healthy infants appropriate for gestational age, without direct complications related to the high training load. One infant experienced mild perinatal hypoxia, a known risk in twin pregnancies, but this was not attributed to the ultramarathon training.

In the second pregnancy, the ultramarathoner increased both distance and training pace, averaging about 157.8 km per week and spending over 14 hours per week running, and she even participated in several ultramarathons during pregnancy, achieving high placements. This pregnancy ended with delivery at 36 weeks and 6 days, with a healthy infant appropriate for gestational age.

The results of this remarkable case indicate that advanced endurance activity, even at very high volume and intensity, does not necessarily lead to adverse perinatal outcomes, at least in selected, highly trained athletes. At the same time, the authors emphasize that such observations cannot be directly generalized to the broader population of pregnant women and must be interpreted in the context of individual predispositions and medical assessment.

The study "Training Characteristics During Pregnancy and Postpartum in the World's Most Successful Cross Country Skier" (Solli GS, 2018) is a case report analyzing the training of one of the world's most decorated cross-country skiers during pregnancy and the first 61 weeks postpartum. It examined training characteristics, volume, and intensity, including running and other endurance activities, broken down by trimester and postpartum phases.

In the first trimester of the 40-week pregnancy, total training volume averaged about 12.9 hours per week, increasing to about 18.3 hours per week in the second trimester and decreasing to 8.8 hours per week in

the third trimester. Low-intensity sessions predominated, moderate-intensity training accounted for a small percentage, and high-intensity training was very rare. In the first two trimesters, the athlete maintained a similar proportion of general activities, such as running, as before pregnancy, whereas in the third trimester the amount of running was reduced, reflecting adaptation to physiological changes and the growing load on the body.

Postpartum, training volume gradually returned toward pre-pregnancy levels, although the early postpartum phases were characterized by variable intensity and modification of activities, especially when health issues such as sacral fractures temporarily limited running and high-intensity training, resulting in a greater proportion of cycling. The study also reported changes in fitness – VO_2 at lactate threshold dropped to about 90% of pre-pregnancy values in the second trimester but returned to near pre-pregnancy levels in later postpartum weeks – and body composition, with increases in body mass and body fat percentage, and decreases in lean body mass and bone mineral density, which gradually returned to pre-pregnancy values during preparation for subsequent competitions.

From this case, it can be concluded that highly trained athletes can tolerate intensive and prolonged training during pregnancy, including running, with appropriate modifications in volume and intensity according to trimester and bodily responses. This suggests the possibility of individualized adaptation of running training for pregnant athletes, although these findings must be interpreted cautiously as they are based on a single highly specialized case, and physiological adaptations and training safety may differ for recreational or less trained women.

The article "Is fetal well-being jeopardised during high-intensity interval training?" (Dalhaug EM, 2025) examines the short-term effects of high-intensity interval training (HIIT) on fetal well-being in pregnant women and is one of the more recent experimental studies in this area. The study included both recreational and competitive athletes who performed a series of five 5-minute high-intensity intervals on a treadmill or stationary bike with rest periods between intervals, at an intensity corresponding to 89–90% of the mother's estimated maximum heart rate and about 16–17 on the Borg RPE scale. Fetal heart rate and placental blood flow were monitored during the rest periods.

During treadmill sessions, there were instances of prolonged fetal bradycardia (<100 beats/min) and tachycardia (>180 beats/min), which were sufficient to stop exercise in some cases, but both bradycardia and tachycardia normalized within minutes after exercise cessation. No such episodes occurred during cycling. Despite these incidents, the overall interpretation of the study suggests that performing a few high-intensity intervals by active pregnant women does not appear to pose a lasting risk to fetal well-being, as no persistent abnormalities were observed and parameters returned to normal after exercise.

The study thus provides empirical evidence that short bouts of intense activity, including interval running, can be tolerated by pregnant women without obvious long-term negative effects on the fetus, although transient physiological responses occur during exercise and should be considered when planning high-intensity activity in pregnancy.

The study "Exploring pregnancy and postpartum experiences among geographically diverse elite athletes: A qualitative study" (McGregor B, 2025) explores the experiences of elite runners from around the world who combined a competitive sports career with pregnancy and returning to running postpartum. In this qualitative analysis, in-depth interviews were conducted with 19 elite-level runners from 14 different countries who became pregnant and subsequently returned to high-level sport.

Participants reported that the decision to become a mother was associated with concerns about the impact of pregnancy on their athletic careers, including potential consequences for sponsors, relationships with coaches, and sports organizations, as well as conflicts between their running ambitions and the expectations of the sporting environment. The athletes emphasized that many professionals, including coaches and physicians, had limited knowledge about training during pregnancy and postpartum, which complicated decisions about continuing running and adapting workouts to their changing physiology.

After returning to elite competition, some runners experienced less performance pressure and simultaneously greater motivation, often attributing improved results to a shift in perspective and priorities following childbirth. The findings highlight that psychological factors, athletic identity, and environmental support play a critical role in how pre-pregnancy runners manage training during pregnancy and plan their return to running postpartum, and that lack of adequate support can influence their experiences and training decisions.

3. Studies conducted using animal models.

The article "A reduction in voluntary physical activity in early pregnancy in mice is mediated by prolactin" (Ladyman SR, 2021) does not directly address humans or running training in pregnant women but is an experimental study in a animal model that provides biological insights into changes in physical activity in early pregnancy. The authors showed that pregnant mice exhibit a rapid and marked reduction in voluntary physical activity, observable very early in pregnancy, suggesting that decreased activity is not always a conscious choice but may have hormonal and neurophysiological underpinnings. The study demonstrated that the hormone prolactin, whose secretion rises quickly after fertilization, plays a key role in suppressing motivation for physical activity—removal of prolactin receptors in specific brain regions of mice significantly attenuated this effect. The results thus indicate adaptive biological mechanisms that may explain reduced willingness or capacity for running and other forms of exercise in early pregnancy, independent of conscious choice. While these data come from an animal model and cannot be directly extrapolated to humans, they may provide an important theoretical context for understanding the commonly observed decline in physical activity among women in the first weeks or months of pregnancy, pointing to possible physiological factors that reduce the drive and ability for more intense exercise.

The study "Perinatal running training reversed postnatal anxiety and depressive-like behavior and cognitive impairment in mice following prenatal subchronic variable stress" (Zhou L, 2024) investigated forty pregnant mice divided into groups with and without exposure to prenatal subchronic variable stress and with and without running training throughout pregnancy and lactation. After birth, maternal behaviors, anxiety-like and depressive-like behaviors, cognitive functions, hormonal parameters, and hippocampal neurogenesis were assessed. Results showed that prenatal stress reduced maternal care, increased anxiety- and depression-like behaviors, impaired cognitive function postpartum, increased hypothalamic-pituitary-adrenal (HPA) axis activity, decreased prolactin levels, and reduced hippocampal neurogenesis. However, mice that performed running training during pregnancy and lactation showed markedly attenuated stress effects, exhibiting better maternal behaviors, lower anxiety and depressive-like symptoms, improved cognition, reduced HPA activity, and increased prolactin levels and hippocampal neurogenesis. Although these results from a mouse model cannot be directly translated to humans, they suggest that running or physical activity around the perinatal period may modulate stress and its neurobehavioral consequences. In the context of your article, such basic research provides a biological rationale for hypothesizing that moderate physical activity, including running, could benefit mental health and physiological adaptation during pregnancy and postpartum, while clinical studies in pregnant women are necessary to confirm these effects.

The study "Maternal exercise during pregnancy promotes physical activity in adult offspring" (Eclarinal JD, 2016) examined how physical activity in pregnant female mice affects the later behavior of their offspring, focusing on potential mechanisms of prenatal programming. Females were randomly assigned to conditions allowing voluntary physical activity (freely rotating running wheel) or restricting it (locked wheel) before and during pregnancy. In adult offspring, spontaneous physical activity, wheel-running behavior, metabolic parameters, body composition, and energy expenditure were assessed. Offspring of active mothers exhibited higher levels of physical activity in adulthood, with this effect particularly pronounced in female offspring. No significant lasting differences in body weight or composition were observed under conditions without access to activity later in life. The authors suggest that prenatal maternal activity can influence long-term patterns of physical behavior in offspring through biological programming mechanisms. Although this study used an animal model and does not directly address running during pregnancy in humans, the results indicate potential long-term positive effects of maternal physical activity on offspring health and health-promoting behaviors, supporting the notion that moderate prenatal exercise may be beneficial, while caution is needed due to interspecies differences.

The study "Starting maternal exercise, unlike reducing the intensity of exercise during pregnancy, prevents memory deficits in female offspring subject to maternal deprivation" (Carrazoni GS, 2023) investigated the effects of physical activity in pregnant female rats on offspring cognitive function, particularly under conditions of early-life maternal deprivation, which in animal models leads to memory impairments and increased oxidative stress in brain structures such as the hippocampus. Females were assigned to experimental groups: some began running only after pregnancy was confirmed, some trained before pregnancy and continued exercise at the same intensity, some reduced exercise intensity after conception, and a control group remained inactive. Offspring were then assessed for spatial and recognition memory, as well as markers of oxidative stress in brain tissue. Results showed that initiating exercise during pregnancy and maintaining consistent intensity protected against memory deficits induced by maternal deprivation, whereas merely

reducing the intensity of prior exercise did not. Offspring of active mothers performed better in behavioral tests and exhibited lower hippocampal oxidative stress, suggesting neuroprotective mechanisms linked to prenatal physical activity. Although this study used an animal model and cannot be directly extrapolated to pregnant women, its findings support the concept of prenatal biological programming, whereby the intrauterine environment, including maternal physical activity, can influence offspring neural development and later cognitive function.

The study "Running Exercise in Obese Pregnancies Prevents IL-6 Trans-signaling in Male Offspring" (Bae-Gartz I, 2016) examined the effects of maternal running during pregnancy under conditions of obesity on metabolic parameters and inflammatory signaling in offspring using an animal model. Female mice fed a high-fat diet (HFD) were divided into two groups – sedentary controls and those with access to a running wheel for voluntary exercise during pregnancy. Offspring were then analyzed for body weight, glucose tolerance, and inflammatory markers, particularly interleukin 6 (IL-6) and its signaling pathways in tissues. Both groups of offspring, HFD and HFD plus running, showed increased body and fat mass, but only offspring of sedentary HFD mothers had elevated serum IL-6, higher IL-6 gene expression in white adipose tissue, and increased STAT3 phosphorylation in the hypothalamus, indicating activation of inflammatory pathways and disrupted cytokine signaling. In contrast, offspring of mothers that ran during pregnancy exhibited significantly reduced changes, with partial normalization of IL-6-related gene expression and signaling, suggesting that maternal exercise mitigated the pro-inflammatory effects of a high-fat diet and improved metabolic outcomes, including glucose tolerance, independently of offspring body weight. Although this experiment used an animal model and focused on obesity as a metabolic context, the findings indicate that running during pregnancy can modulate molecular factors related to inflammation and metabolism in offspring, supporting the broader view of prenatal physical activity benefits, including metabolic protection and mitigation of maternal environmental risk factors.

Discussion

The collected and analyzed studies – encompassing recreational runners, elite and sub-elite athletes, as well as animal models – indicate that running during pregnancy is a complex, multidimensional phenomenon that is highly dependent on individual context. A comprehensive review of the literature suggests that, in the absence of medical contraindications and with appropriate adjustment of training intensity and volume, running can be a safe component of physical activity during pregnancy and, in some cases, may provide health benefits for the mother and potentially for the child.

Biomechanical studies show that pregnancy significantly alters running patterns – changes occur in speed, trunk and pelvic rotation, and stabilizing muscle activation. Observed adaptations (e.g., increased activity of the back extensors, altered timing of gluteal muscles) should be interpreted as compensatory mechanisms in response to increasing body mass and a shifted center of gravity. Importantly, some changes persist postpartum, highlighting the need for targeted movement re-education during the postnatal period.

Regarding physiological responses, data on perceived exertion (RPE) and cardiorespiratory parameters indicate that subjective intensity does not always reflect the actual energetic cost of exercise during pregnancy. Hemodynamic adaptations (increased blood volume, elevated resting heart rate) can alter the relationship between objective and subjective load. In practice, this means that monitoring running intensity in pregnancy should combine subjective and objective methods (e.g., heart rate control), especially during higher-intensity sessions.

Studies on thermoregulation are also informative – even intense running intervals did not lead to core temperature exceeding values considered unsafe under controlled conditions. This suggests that in healthy, well-trained women, heat dissipation mechanisms remain effective, although caution is still required in high ambient temperatures or during dehydration.

Observational and randomized studies indicate that moderate aerobic activity during pregnancy – including walking, jogging, or running – may limit excessive weight gain and reduce the risk of gestational diabetes (GDM) without increasing the risk of preterm birth. In the context of trial of labor after cesarean (TOLAC), regular physical activity was associated with higher rates of successful vaginal birth, suggesting a potential influence of overall fitness on labor outcomes.

However, not all interventions show uniformly positive effects – in studies of women with overweight or obesity, supervised exercise programs did not always translate into improved subjective well-being or postpartum weight maintenance, although beneficial metabolic changes (e.g., insulin sensitivity) were

observed. This indicates that the effects of running and aerobic activity may depend on baseline metabolic profile, adherence to the program, and psychosocial factors.

A high proportion of runners reported pain in the pelvis, sacroiliac joints, and lower back, highlighting that pregnancy imposes significant musculoskeletal strain. While moderate activity may protect against back and pelvic pain in the general pregnant population, the frequency of complaints remains high among women who continue running. Previous running-related injuries appear to be one of the strongest predictors of pain during pregnancy.

Special attention should be given to pelvic floor function. Both cross-sectional studies and risk factor analyses for return to running postpartum indicate that weakness in this muscle group is associated with poorer sexual function and a higher risk of stress urinary incontinence (SUI), particularly when returning to running too early. These data strongly support the inclusion of pelvic floor and core stabilization training as an integral part of programs for pregnant and postpartum runners.

International expert consensus emphasizes a staged, individualized return to running, including an initial recovery phase, progression through walk-run sessions, and incorporation of strength training. In recreational runners, factors facilitating return to running included maintaining activity during pregnancy and higher pre-pregnancy fitness levels. In elite runners, an earlier return to training is often observed, and in some cases, even improved performance is noted 1–3 years postpartum.

At the same time, systematic reviews indicate an increased risk of injuries, including stress fractures, in the postpartum period among athletes returning to intensive training. Case reports show that very high training loads during pregnancy can be tolerated by selected, highly trained women, but this cannot form a basis for generalization to the overall population.

Qualitative studies reveal that running during pregnancy is not only a health behavior but also an element of identity. For many women, maintaining activity is a way to preserve continuity of “being a runner,” control over the body, and a sense of agency. Simultaneously, inconsistent or overly general guidance from medical personnel can undermine trust in personal perceptions and lead to unnecessary discontinuation of activity. This highlights the need for evidence-based, consistent clinical communication.

Animal studies provide potential biological mechanisms underlying these observations. They indicate, among other things, the role of prolactin in the natural decline in motivation for activity during early pregnancy, possible stress-reducing and neuroprotective effects of running in the perinatal period, and potential prenatal programming effects influencing offspring metabolism and activity. While translating these findings to humans requires caution, they provide biological justification for hypotheses about the systemic impact of prenatal activity.

The analyzed literature is characterized by considerable methodological heterogeneity – many studies are observational, retrospective, or qualitative, and sample sizes are often small. In elite athletes, case reports and survey studies dominate, limiting the ability to draw strong causal conclusions. Long-term, well-controlled interventional studies evaluating specific running protocols during pregnancy are lacking.

Despite these limitations, the accumulated evidence allows several practical conclusions:

1. Running during pregnancy can be safe for women without medical contraindications if appropriately modified.
2. Individualization of training load and intensity monitoring are crucial.
3. Pelvic floor and core stabilization training should be standard practice.
4. Return to running postpartum requires staged progression and assessment of functional readiness.
5. Interdisciplinary support (physician, physiotherapist, coach, dietitian) enhances safety and effectiveness of the process.

Conclusions

The conducted literature analysis indicates that running during pregnancy – in the absence of medical contraindications and with appropriate modification of training loads – can be a safe and potentially beneficial form of physical activity. However, individual context is crucial: pre-pregnancy fitness level, health status, pregnancy progression, and the quality of medical and physiotherapeutic support all play key roles.

Available evidence suggests that moderate running can support weight management, metabolic profile, and overall cardiorespiratory fitness without increasing the risk of preterm birth in healthy women. At the same time, the high prevalence of musculoskeletal complaints and the potential risk of pelvic floor dysfunction highlight the necessity of systematic functional assessment and targeted stabilization training.

Regarding return to running postpartum, evidence clearly supports a staged approach based on functional criteria rather than simply the time elapsed since delivery. Progressing intensity too early may increase the risk of overuse injuries and stress urinary incontinence, particularly in women without adequate pelvic floor preparation.

It should be emphasized that the current evidence base remains heterogeneous and largely relies on observational studies, surveys, and case reports, especially among elite athletes. Further well-designed interventional studies are needed to determine optimal intensity, volume, and frequency ranges for running across different pregnancy trimesters and the postpartum period.

In conclusion, running during pregnancy should not be considered inherently risky nor universally recommended – its safety and effectiveness depend on individual adaptation, monitoring, and an interdisciplinary clinical approach. In practice, this requires personalized guidance, evidence-based decision-making, and consideration of the woman's perspective and experience.

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REFERENCES

1. Bagwell, J. J., Avila, E., Reynolds, N., Smith, J. A., Valenzuela, K., & Katsavelis, D. (2024). Running biomechanics differ during and after pregnancy compared to females who have never been pregnant. *Gait & Posture*, 109, 277–283. <https://doi.org/10.1016/j.gaitpost.2024.02.004>
2. Woodroffe, L., Slayman, T., Paulson, A., Kruse, N., Mancuso, A., & Hall, M. (2025). Return to running for postpartum elite and subelite athletes. *Sports Health*, 17(3), 614–620. <https://doi.org/10.1177/19417381241256973>
3. Deering, R. E., Donnelly, G. M., Brockwell, E., Bø, K., Davenport, M. H., De Vivo, M., Dufour, S., Forner, L., Mills, H., Moore, I. S., Olson, A., & Christopher, S. M. (2024). Clinical and exercise professional opinion on designing a postpartum return-to-running training programme: An international Delphi study and consensus statement. *British Journal of Sports Medicine*, 58(4), 183–195. <https://doi.org/10.1136/bjsports-2023-107490>
4. Christopher, S. M., Donnelly, G., Brockwell, E., Bø, K., Davenport, M. H., De Vivo, M., Dufour, S., Forner, L., Mills, H., Moore, I. S., Olson, A., & Deering, R. E. (2024). Clinical and exercise professional opinion of return-to-running readiness after childbirth: An international Delphi study and consensus statement. *British Journal of Sports Medicine*, 58(6), 299–312. <https://doi.org/10.1136/bjsports-2023-107489>
5. Tenforde, A. S., Toth, K. E., Langen, E., Fredericson, M., & Sainani, K. L. (2015). Running habits of competitive runners during pregnancy and breastfeeding. *Sports Health*, 7(2), 172–176. <https://doi.org/10.1177/1941738114549542>
6. Wyatt, H. E., Sheerin, K., Hume, P. A., & Hébert-Losier, K. (2024). Prevalence and risk factors for musculoskeletal pain when running during pregnancy: A survey of 3102 women. *Sports Medicine*, 54(7), 1955–1964. <https://doi.org/10.1007/s40279-024-01994-6>
7. Waddington, G. S. (2016). Exercise and weight gain in pregnancy. *Journal of Science and Medicine in Sport*, 19(4), 277. <https://doi.org/10.1016/j.jsams.2016.02.007>

8. de Melo Silva, R., Da Roza, T. H., Secchi, L. L. B., da Silva Serrão, P. R. M., & Resende, A. P. M. (2023). Can running influence women's sexual function? *International Urogynecology Journal*, 34(4), 905–911. <https://doi.org/10.1007/s00192-022-05266-7>
9. Kimber, M. L., Meyer, S., McHugh, T. L., Thornton, J., Khurana, R., Sivak, A., & Davenport, M. H. (2021). Health outcomes after pregnancy in elite athletes: A systematic review and meta-analysis. *Medicine & Science in Sports & Exercise*, 53(8), 1739–1747. <https://doi.org/10.1249/MSS.0000000000002617>
10. Darroch, F., Schneeberg, A., Brodie, R., Ferraro, Z. M., Wykes, D., Hira, S., Giles, A. R., Adamo, K. B., & Stellingwerff, T. (2023). Effect of pregnancy in 42 elite to world-class runners on training and performance outcomes. *Medicine & Science in Sports & Exercise*, 55(1), 93–100. <https://doi.org/10.1249/MSS.0000000000003025>
11. Ladyman, S. R., Carter, K. M., Gillett, M. L., Aung, Z. K., & Grattan, D. R. (2021). A reduction in voluntary physical activity in early pregnancy in mice is mediated by prolactin. *eLife*, 10, e62260. <https://doi.org/10.7554/eLife.62260>
12. Zhou, L., Wu, Z., Li, Y., Xiao, L., Wang, H., & Wang, G. (2024). Perinatal running training reversed postnatal anxiety and depressive-like behavior and cognitive impairment in mice following prenatal subchronic variable stress. *Pharmacology Biochemistry and Behavior*, 245, 173898. <https://doi.org/10.1016/j.pbb.2024.173898>
13. Bains, G., Carter, S., Hayman, M. J., & Davenport, M. H. (2024). Running for two (or three!): The journey of an ultramarathoner across two pregnancies. *Journal of Applied Physiology*, 137(6), 1659–1665. <https://doi.org/10.1152/jappphysiol.00488.2024>
14. Eclarinal, J. D., Zhu, S., Baker, M. S., Piyarathna, D. B., Coarfa, C., Fiorotto, M. L., & Waterland, R. A. (2016). Maternal exercise during pregnancy promotes physical activity in adult offspring. *FASEB Journal*, 30(7), 2541–2548. <https://doi.org/10.1096/fj.201500018R>
15. Moore, I. S., James, M. L., Brockwell, E., Perkins, J., Jones, A. L., & Donnelly, G. M. (2021). Multidisciplinary, biopsychosocial factors contributing to return to running and running related stress urinary incontinence in postpartum women. *British Journal of Sports Medicine*, 55(22), 1286–1292. <https://doi.org/10.1136/bjsports-2021-104168>
16. Broberg, L., Ersbøll, A. S., Backhausen, M. G., Damm, P., Tabor, A., & Hegaard, H. K. (2015). Compliance with national recommendations for exercise during early pregnancy in a Danish cohort. *BMC Pregnancy and Childbirth*, 15, 317. <https://doi.org/10.1186/s12884-015-0756-0>
17. Gjestvang, C., Olsen, M. L., Dalhaug, E. M., & Haakstad, L. A. H. (2024). Rating of perceived exertion as a tool for managing exercise intensity during pregnancy: A scoping review. *BMJ Open*, 14(10), e086682. <https://doi.org/10.1136/bmjopen-2024-086682>
18. Carrazoni, G. S., das Neves, B. S., Dos Santos Soares, M., Lima, K. R., & Mello-Carpes, P. B. (2023). Starting maternal exercise, unlike reducing the intensity of exercise during pregnancy, prevents memory deficits in female offspring subject to maternal deprivation. *Brain Research*, 1808, 148337. <https://doi.org/10.1016/j.brainres.2023.148337>
19. Solli, G. S., & Sandbakk, Ø. (2018). Training characteristics during pregnancy and postpartum in the world's most successful cross country skier. *Frontiers in Physiology*, 9, 595. <https://doi.org/10.3389/fphys.2018.00595>
20. Bae-Gartz, I., Janoschek, R., Kloppe, C. S., Vohlen, C., Roels, F., Oberthür, A., Alejandro Alcazar, M. A., Lippach, G., Muether, P. S., Dinger, K., Ferrari, N., Graf, C., Dötsch, J., & Hucklenbruch-Rother, E. (2016). Running exercise in obese pregnancies prevents IL-6 trans-signaling in male offspring. *Medicine & Science in Sports & Exercise*, 48(5), 829–838. <https://doi.org/10.1249/MSS.0000000000000835>
21. Ohlendorf, J. M., Anklam, A. L., & Gardner, L. (2019). "I am a runner": A qualitative analysis of women-runners' pregnancy experiences. *Women and Birth*, 32(3), e307–e314. <https://doi.org/10.1016/j.wombi.2018.07.021>
22. Rodrigues-Denize, N., Zolnikov, B. T. R., & Furio, F. (2024). A systematic review on the physical, mental, and occupational effects of exercise on pregnant women. *Dialogues in Health*, 4, 100181. <https://doi.org/10.1016/j.dialog.2024.100181>
23. Giles, A. R., Philipps, B., Darroch, F. E., & McGettigan-Dumas, R. (2016). Elite distance runners and breastfeeding. *Journal of Human Lactation*, 32(4), 627–632. <https://doi.org/10.1177/0890334416661507>
24. Dalhaug, E. M., Sanda, B., Bø, K., Brown, W. J., Øvstedal, K., Brevik-Persson, S., & Haakstad, L. A. H. (2025). Is fetal well-being jeopardised during high-intensity interval training? *BMJ Open Sport & Exercise Medicine*, 11(2), e002496. <https://doi.org/10.1136/bmjsem-2025-002496>
25. Rao, J., Fan, D., Lu, D., Liu, Y., Wu, Z., He, J., Liu, X., Peng, B., Guo, X., & Liu, Z. (2023). Walking or jogging during pregnancy increases the success rate of vaginal birth after cesarean delivery: A multicenter, retrospective cohort study. *International Journal of Gynecology & Obstetrics*, 162(2), 765–770. <https://doi.org/10.1002/ijgo.14740>
26. Marshall, M. R., & Pivarnik, J. M. (2015). Perceived exertion of physical activity during pregnancy. *Journal of Physical Activity and Health*, 12(7), 1039–1043. <https://doi.org/10.1123/jpah.2013-0458>
27. Alberton, C. L., Bgeginski, R., Pinto, S. S., Nunes, G. N., Andrade, L. S., Brasil, B., & Domingues, M. R. (2019). Water-based exercises in pregnancy: Apparent weight in immersion and ground reaction force at third trimester. *Clinical Biomechanics*, 67, 148–152. <https://doi.org/10.1016/j.clinbiomech.2019.05.021>

28. Garnæs, K. K., Helvik, A. S., Stafne, S. N., Mørkved, S., Salvesen, K., Salvesen, Ø., & Moholdt, T. (2019). Effects of supervised exercise training during pregnancy on psychological well-being among overweight and obese women: Secondary analyses of the ETIP-trial, a randomised controlled trial. *BMJ Open*, 9(11), e028252. <https://doi.org/10.1136/bmjopen-2018-028252>
29. Owe, K. M., Bjelland, E. K., Stuge, B., Orsini, N., Eberhard-Gran, M., & Vangen, S. (2016). Exercise level before pregnancy and engaging in high-impact sports reduce the risk of pelvic girdle pain: A population-based cohort study of 39 184 women. *British Journal of Sports Medicine*, 50(13), 817–822. <https://doi.org/10.1136/bjsports-2015-094921>
30. McGregor, B., McGrath, R., Young, J., & Nottle, C. (2025). Exploring pregnancy and postpartum experiences among geographically diverse elite athletes: A qualitative study. *Journal of Science and Medicine in Sport*, 28(2), 101–109. <https://doi.org/10.1016/j.jsams.2024.10.001>
31. Brevik-Persson, S., Gjestvang, C., Mass Dalhaug, E., Sanda, B., Melau, J., & Haakstad, L. A. H. (2024). Cool mama: Temperature regulation during high-intensity interval running in pregnant elite and recreational athletes. *Journal of Exercise Science & Fitness*, 22(4), 429–437. <https://doi.org/10.1016/j.jesf.2024.09.003>
32. Garnæs, K. K., Mørkved, S., Salvesen, K. Å., Salvesen, Ø., & Moholdt, T. (2018). Exercise training during pregnancy reduces circulating insulin levels in overweight/obese women postpartum: Secondary analysis of a randomised controlled trial (the ETIP trial). *BMC Pregnancy and Childbirth*, 18(1), 18. <https://doi.org/10.1186/s12884-017-1653-5>
33. Blyholder, L., Chumanov, E., Carr, K., & Heiderscheit, B. (2017). Exercise behaviors and health conditions of runners after childbirth. *Sports Health*, 9(1), 45–51. <https://doi.org/10.1177/1941738116673605>