



Return-to-Sport After Pregnancy: Factors Influencing Performance, Recovery, and Injury Risk in Elite Female Athletes

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Submitted to: Journal of International Research & Multidisciplinary Innovation (JIRMI)

Date: 17 July 2026

Abstract

The number of elite female athletes who continue competitive careers through pregnancy and childbirth has increased substantially over the past decade, yet evidence-based guidance on the postpartum return to sport remains limited relative to the scale and complexity of the physiological transition involved. This review synthesizes the available epidemiological, biomechanical, and qualitative literature on return-to-sport outcomes among elite female athletes following childbirth, with attention to three interrelated domains: physiological and musculoskeletal recovery, injury risk, and athletic performance trajectories. Pregnancy and delivery induce substantial and only partially reversible adaptations across the cardiovascular, musculoskeletal, and pelvic floor systems, including diastasis recti abdominis, which affects the substantial majority of women in the immediate postpartum period, and pelvic floor dysfunction, which manifests as stress urinary incontinence in approximately one-third of postpartum runners. Elite athletes return to training considerably earlier than non-athletic postpartum controls, with cohort data indicating that a majority resume sport-specific activity within six weeks of delivery, a timeline that coincides with, and may be constrained by, tissue healing windows for cesarean or perineal trauma. Injury surveillance data document elevated rates of postpartum stress fracture and training-related injury relative to pre-pregnancy baselines, patterns plausibly connected to relative energy deficiency in sport, lactation-associated hormonal changes, and residual pelvic girdle instability. Performance outcome data, drawn primarily from elite distance running cohorts, suggest that a substantial proportion of athletes match or exceed pre-pregnancy performance benchmarks within twelve to twenty-four months of childbirth, although considerable inter-individual variability and a continued absence of sport-specific, evidence-based return-to-sport protocols constrain

generalization. The review further examines the emergence of structured return-to-sport frameworks, including the six-phase biopsychosocial model, and considers the sociocultural, institutional, and psychological barriers, including maternity policy gaps, sponsorship insecurity, and identity renegotiation, that shape the postpartum athletic experience independently of physiological recovery status.

Keywords: postpartum athlete, return to sport, pelvic floor dysfunction, diastasis recti, relative energy deficiency in sport, elite female athletes, athletic performance, injury risk

1. Introduction

Many female athletes reach their peak in their athletic career at the same time as their peak reproductive years, a situation that traditionally has been a dilemma for the best of female athletes between continuing to play and becoming a mother. The perception of pregnancy as the end of a sportswoman's prime, even in the circles of sport, was a common one until quite recently. This is now being called into question, as an increasing number of top sports performers are running, football, netball, cross country skiing and other sports during pregnancy and competing at the highest level one to two years after giving birth¹. The evidence base to support the transition of the postpartum elite athlete, however, is still very limited in comparison to the physiological complexity of the transition itself. Many of the changes that occur during pregnancy continue, are only partially resolved, or may become evident in the weeks and months following childbirth, in the cardiovascular, respiratory, musculoskeletal, endocrine and pelvic floor systems. Added to this physiological recovery process is the need, unique to the elite athlete, to recover not just the functional activities of daily living, but the highest levels of neuromuscular power, aerobic capacity and sport-specific technical skill – often on a compressed schedule defined by qualification requirements, sponsorship deals and Olympic or major championship cycles. Traditional return-to-sport recommendations have been derived from two different, albeit somewhat overlapping, and limited evidence bases: general postpartum exercise guidelines for recreationally active women and musculoskeletal guidelines for return to sport in non-postpartum populations. Neither can adequately reflect the unique physiological and psychosocial characteristics of the postpartum elite athlete². This review aims to collate the current body of evidence from three related areas that are relevant to the postpartum training and competition: first, physiological and musculoskeletal changes of pregnancy and childbirth that are most relevant to postpartum training and competition; second, documented injury risk associated with the return to elite sport post-partum; and third, empirical evidence on postpartum athletic performance

trajectories, specifically the time period and risk of athletes returning to match or exceed competitive benchmarks pre-pregnancy. The review ends with a discussion of structured return-to-sport guidelines, sociocultural and institutional barriers, and methodological limitations that persist in preventing evidence-based practice in this area.

2. Physiological and Musculoskeletal Adaptations of Pregnancy and the Postpartum Period

2.1 The cardiovascular and systemic adaptations

During pregnancy, there is significant increase in the maternal blood volume, heart rate, and cardiocirculatory output (CO) in order to support fetal-placental blood flow, while vascular resistance of the vessels is altered, which do not normalize until several weeks to months after delivery. These cardiovascular adaptations are also linked to training load in an incompletely understood manner and most of the baseline data on maternal cardiovascular physiology have been obtained in sedentary and recreationally active rather than in athletes who are used to long-duration high-intensity aerobic and anaerobic training. Exercise and pregnancy: expert group report 2016/17 highlights that moderate intensity exercise during pregnancy is safe for the mother and fetus but that intensities that raise maternal heart rate above about 90% max may be associated with altered fetal heart rate responses, which has implications for elite athletes used to training at or near maximal intensity (1).

2.2 Diastasis Recti Abdominis

The separation and thinning of the Linea alba between the two bellies of the rectus abdominis (DRA), is a normal physiologic accommodation to the expansion of the uterus that occurs in essentially all women during the third trimester. About half of these cases get better on their own in the first postpartum few weeks with the other half remaining and possibly needing focused rehabilitation. In a retrospective cohort of 229 women, the prevalence of DRA was 82.6% in the first postnatal year, and caesarean delivery and several previous pregnancies were important risk factors for DRA to persist. The Linea alba is not only an aesthetic matter or an issue of abdominal contour; due to its importance as an attachment point for the transfer of abdominal force, its weakness has been shown to be directly correlated with weaker abdominal muscle function, increased abdominal pain, and, in some but not all studies, a higher prevalence of concurrent pelvic floor dysfunction and low back/ pelvic girdle pain, all of which have direct relevance for the

athlete's ability to generate and transmit force during the movement patterns required for their sport. The pelvic floor dysfunction and urinary incontinence is a topic to be covered. During vaginal delivery, the pelvic floor musculature is subjected to significant mechanical and neurological stress and, to a lesser, though not insignificant extent, during caesarean delivery, thus making PPD women vulnerable to a range of pelvic floor dysfunctions (PFD), such as stress urinary incontinence, fecal incontinence, pelvic organ prolapses and pelvic pain. Population-level data have shown that at least 55.8% of women experiencing the symptoms of pelvic floor dysfunction were also experiencing urinary incontinence, 10.4% were experiencing symptoms of fecal incontinence, 14.0% were experiencing symptoms of uterine prolapse, and 18.7% had symptoms of pelvic pain, with higher parity, instrumental vaginal delivery, and fetal macrosomia being risk factors. Vaginal heaviness, a marker of pelvic organ prolapses, and stress urinary incontinence were both independently associated with athletes reporting that they delayed or avoided higher impact training, with about one third of postpartum runners reporting each symptom within the specific context of postpartum return to running. The pelvis is an important structure for the transfer of ground reaction force from the lower limb to the trunk during activities involving impact loading such as running and jumping, so that when the pelvis is dysfunction without resolution, its ability to transmit force and to tolerate the impact loading demands of the sport may be impaired affecting symptom burden and biomechanical efficiency. Independent studies of elite nulliparous (never-pregnant) athletes have revealed meaningfully changed pelvic floor muscle function with high-impact sport participation, even without childbirth, suggesting elite training represents an additional risk exposure which adds to childbirth and delivery².

2.3 Bone, Ligament, and Soft-Tissue Considerations

Other hormones which are associated with pregnancy and relaxing increase the elastin content of ligaments, which is advantageous for parturition but could affect the stability of joints during sporting activities with high loads. Milk production itself has been associated with transient decreases in bone mineral density, due to the calcium requirement of lactation, that usually return to normal after weaning, though they may add to other predispositions to low bone mineral density in athletes who experience low energy availability or menstrual dysfunction. This is not a hypothetical issue as postpartum stress fractures have been reported in elite athletic populations, which will be discussed in Section 4.

3. Relative Energy Deficiency, Nutritional Status, and Reproductive Health

There is growing evidence that pre-conception relative energy deficiency in sport (REDs) is associated with negative pregnancy outcomes and thus, negatively impacts on postpartum outcomes. In a large survey-based investigation of 1025 women who had previously been pregnant, 6.1% had been diagnosed as suffering from REDs and 20.5% said they had had a history of secondary amenorrhea before they became pregnant. The odds of having adverse outcomes in pregnancy or delivery were 3.5 times greater for athletes diagnosed with REDs before becoming pregnant versus athletes with no previous diagnosis of REDs, and 2.6 times greater for athletes who had secondary amenorrhea alone versus athletes who had never been diagnosed with REDs, but not for athletes who had had a previous diagnosis of secondary amenorrhea without a diagnosis of REDs.¹ These findings support the broader concept of REDs that the metabolic and endocrine consequences of chronic low energy availability are not limited to the reproductive axis but have systemic consequences, including reproductive and perineal health consequences, that are not apparent just from resolution of menstrual symptoms². Furthermore, the postpartum period is a time of increased energy demand due to lactation, tissue healing and the resumption of training, and this puts all athletes at risk of negative energy balance, even those not at risk of REDs. The medicinal model of nutritional and musculoskeletal status assessment is reactive, with nutrition and MSK problems only being dealt with when they become clinically apparent, while the more recently advocated approach is pro-active, and involves screening the full generation from pre-conception counselling through to return to full training load post-partum.

4. Return to Sport After an injury

There is limited epidemiological data on direct injuries in elite postpartum athletes, but existing cohort data suggests that there is a measurable increase in musculoskeletal injury risk compared to pre-pregnancy baseline. Among the four studied athletes (12%) who sustained training induced injuries during the third trimester of pregnancy, 12% also developed postpartum stress fracture, with all athletes with SIs returning to sport within 6 wks from delivery, and all breastfeeding at the time of the injuries; this time course suggests that there was a cumulative effect of early return to HIL, reduction in BMD during lactation, and incomplete musculoskeletal recovery³. The same population identified urinary incontinence in 21% of elite athletes and 27% of active controls, which is similar to the literature on pelvic floor dysfunction in the postpartum period (Section 2.3), suggesting that there is no protection from, and likely not significant differences from, community rates of postpartum pelvic floor morbidity in elite athletes. Our survey-based and qualitative study of Canadian elite athletes also found that during the resumption of training period following postpartum, they experienced musculoskeletal pain and injury at various locations, and that these

injuries were partially attributed to the lack of evidence-based guidance, to returning to training too early to be physiologically prepared, and to training load increases being greater than the tissue healing rate. A limited institutional support environment, such as poor childcare facilities and financial ramifications associated with sponsorship or funding renewal, may directly support the athlete's return to sport plan, increasing the likelihood of injury above and beyond what would be predicted by their physiological capacity to return.

5. Structured Return-to-Sport Frameworks

In the face of the lack of general postpartum exercise advice and general musculoskeletal return-to-sport protocols, sport-medicine researchers have suggested specific postpartum return-to-sport protocols. Donnelly and colleagues followed the widely cited 2016 Consensus Statement on Return to Sport, which conceptualizes the process of return to sport as a continuum of Return to Participation, Return to Sport, and Return to Performance, and added the "6 Rs" for the postpartum athlete: Ready, Review, Restore, Recondition, Return, and Refine¹. This framework explicitly further integrates into the generic return to sport model elements that are typically not considered in other models, such as pelvic floor health, breast health and lactation, energy availability, disruption of sleep, fear of movement, mental health, and socioeconomic factors, thus taking a whole-systems biopsychosocial approach, rather than a narrow musculoskeletal one. Complementary infographic guidance, published in the British Journal of Sports Medicine, also highlighted the importance of 'graded and criteria-based' progression to postpartum running, including symptom screening of the pelvis, the need to assess how bad the diastasis recti is, and progressive loading benchmarks before progression to higher-impact exercise. Although they have become more sophisticated over time, the empirical evidence supporting these frameworks in truly elite populations is still relatively small, and international Delphi consensus-building groups of clinical and exercise professionals have shown that there remains a lack of consensus on what constitutes readiness, on screening threshold criteria and on the balance between conservative caution and the demands of high-performance sport that comes with the need for expertise.

6. Performance Outcomes Following Return to Elite Sport

6.1 The two cohorts of elite distance runners are analysed to reveal the following evidence

The best quantitative evidence for postpartum performance trajectories exists in elite distance running, where training loads can be easily quantified, and in which several high-profile athletes

have willingly shared their experience of a postpartum comeback. One investigation, looking at 42 elite to world-class runners, showed that training decreased significantly from each trimester of pregnancy, up to the first few months after birth, but then regained pre-pregnancy levels – and indeed surpassed pre-pregnancy levels in a significant group – within 12 to 24 months.¹ In line with this trend, a Canadian study of 10 elite practitioners who became pregnant while participating in competitive sport found that nine re-started training after birth, and five athletes resumed competitive athletic activities, of which four said their athletic performance increased compared to that prior to pregnancy (though the small sample size makes it hard to draw general conclusions from this finding).

6.2 Qualitative and Cross-National Evidence

These quantitative performance trends are given some richness and flesh by qualitative research. In a phenomenological study of 19 elite distance runners from 14 countries, the athletes often reported psychological reorganization of the whole competitive pressure and a change in focus of motivation, from competition towards their child, along with ongoing physical adaptations. The qualitative study of UK-based elite athletes in a variety of sports identified the following themes as the main factors influencing the postpartum return to elite-level activity: physical recovery, expectations for a positive trajectory for the athlete, injury risk, renegotiation of athlete-mother identity, logistical challenges with childcare and structural/institutional barriers such as the provisions and limitations of maternity policies. Both studies suggest that a high number of elite athletes return to and exceed their previous performance levels after a fallopian tube removal, but that it is not inevitable or guaranteed, and depends on their individual physiology and recovery, as well as support from institutions, and access to suitable training advice.

6.3 Sport-Specific Considerations

Findings at the case level and narrative from other sports (professional football (soccer), netball and cross-country skiing) broadly support the running findings and further emphasize sport-specific musculoskeletal and logistical considerations. The research on post-partum return-to-running in competitive footballers has highlighted the importance of matching the PF recovery time frame with the diastasis recti recovery time frame with the demands of field sport which involve multidirectional cutting, jumping and collision, loading patterns that differ to the more sagittal plane loading demands in distance running. When a cesarean delivery was reported in a

published case report of a professional netball player returning to sport, it highlighted the application of graded and criteria-based rehabilitation and drew attention to the compressed timeline of elite sport, and the need for individualized, criteria-based (not purely time-based) clearance decisions based on the survey data, which showed around 71% of postpartum athletes were able to return to some form of training within 6 weeks after delivery².

7. Family and peer influence, cultural identity

The physiological aspect of the transition is only a small part of the transition back to elite sport, as there is also a significant psychological transition. Many athletes transitioning through this experience report a negotiation of the identity of the athlete and the mother, along with feelings of guilt and/or social condemnation for putting performance ahead of maternal responsibilities during their early motherhood years when it is the norm to sacrifice self for others. The sleep disruption caused by infant care further exacerbates training-recovery requirements in a physiologic fashion, yet in a social and logistic way that is fundamentally different for elite athletes in general. Within postpartum return-to-sport programs, fear of movement, specifically for pelvic floor symptoms or the noticeable changes in the body due to pregnancy, has been found to be a separate psychological barrier from physiological readiness of the tissues to return to higher impact exercise training².

8. Sociocultural and Institutional Barriers

The above physiological and psychological factors exist within a larger institutional context that also influences return-to-sport outcomes after pregnancy independently. In some sports, historically, there have been performance clauses or a reduction in payments when a woman becomes pregnant and/or during her postpartum period, which results in direct financial incentives for the athletes to shorten recovery periods or hide their pregnancy from the governing body and sponsors until required by contract. In the late 2010s and early 2020s, there was a focus on changing policies regarding maternity in sport, with changes to a number of sport-sponsoring policies and policies of the sport federations, which were facilitated by public advocacy by prominent elite athletes. However, scoping review evidence revealed that policy coverage, specificity, and consistency across sport federations was highly variable. This structural barrier has been encountered many times in qualitative studies, and has been shown to exacerbate, and in some cases overcome, the purely physiological parameters underpinning a successful return to elite competition postpartum.

9. Methodological Limitations in the Existing Literature

There are several methodological limitations in the conclusions that can be currently drawn from the postpartum elite athlete literature. First, the sample size in almost all cohort and survey studies cited is small, which is as intended should be the case, as there are limited populations of elite athletes who become pregnant during their active athletic careers, and this reflects the limited statistical power and ability to detect moderate-sized effects and to stratify findings by sport, parity, and delivery mode. Second, the literature is largely dominated by retrospective survey and qualitative studies, rather than prospective, hormonally and biomechanically verified cohort studies, which bring about recall bias and restrict the causal inferences of the links between training practices and results. Third, there is a lack of prospective clinical validation of existing return-to-sport frameworks in the context of elite (as opposed to recreational) postpartum individuals, which limits their established clinical value; although it is presumed that the 6 Rs model will be similarly validated in the future. Lastly, geographic and institutional representativeness is still relatively poor, with most studies published from North America, Australia and Europe, and the postpartum experiences and outcomes of elite athletes from elsewhere being studied in much less detail.

10. Implications for Practice

The evidence presented here has implications for a few practical aspects of the multidisciplinary team working with elite postpartum athletes. Return to sport decisions should be criteria based and not time based, including structured assessment of pelvic floor function, diastasis recti severity and the status of energy availability, in addition to the standard musculoskeletal and cardiovascular readiness markers and should reflect the 6 Rs and other similar biopsychosocial frameworks². Therefore, for pre-conception REDs and adverse perinatal outcomes to be associated, proactive screening of nutritional health and menstruation before conception is a useful upstream intervention, as opposed to reactive intervention after, as in the postpartum stage. Psychological factors such as fear of movement and identity issues do not always coincide with the healing of tissue, and formal psychological assessment should be added as a separate part of a return-to-sport evaluation, not expected to fall into place along with tissue healing. Lastly, institutional and policy-level interventions (such as standardized maternity provisions, sponsorship continuity and accessible childcare support) are an essential complement to individual clinical management, as they have been found to be important factors underlying a compressed and higher-risk postpartum return to competition in many studies, though not all.

11. Conclusion

The postpartum return to elite sport is a complex physiologic and psychosocial transition for which there is currently little evidence that it is impossible, but rather is in fact possible, and in many reported examples successful, although not always an easy transition. Elite athletes return to training much sooner than postpartum women who are not athletes, often within 6 weeks of giving birth, when there is still a short time period of unresolved musculoskeletal, pelvic floor, and energy availability issues that are well documented and have links with increased injury risk, such as stress fracture and pelvic floor dysfunction. The performance outcome data, which are mainly from elite distance runners, indicate that a significant number of athletes return to the same level of performance as pre-pregnancy within 1–2 years, but this is dependent on each athlete's recovery process, adequate institutional support and access to sport-specific, evidence-based guidance (which is not necessarily available). While there has been some significant progress with the emergence of structured, biopsychosocial return-to-sport frameworks,² further research is required using prospective, sufficiently powered and geographically diverse designs, as well as continued institutional investment in maternity policy and postpartum athlete support, to move from the current best understanding towards consistently safe and effective practice.

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