Case Reports in Women's Health xxx (xxxx) xxx

Contents lists available at ScienceDirect

Case Reports in Women's Health

journal homepage: www.elsevier.com/locate/crwh

Bone health and pregnancy: Osteoporosis and beyond

ARTICLE INFO

Keywords:
Pregnancy
Osteoporosis
Lactation
Women's health
Muskuloskeletal health
Fetal health

The physiological demands of pregnancy and lactation necessitate substantial adaptations in maternal mineral metabolism, with significant effects on skeletal integrity [1,2]. While osteoporosis of the hip remains the most commonly discussed bone complication of pregnancy, this limited focus fails to capture the broader implications of pregnancy-induced bone remodelling. Gestation and lactation represent periods of accelerated and dynamic skeletal turnover, characterized by increased calcium mobilization, alterations in hormonal regulation (e.g., parathyroid hormone-related protein, oestrogen, calcitonin), and shifts in bone resorption and formation [3,4]. These processes may have long-term consequences for maternal bone health, especially in women with preexisting metabolic risk factors. Therefore, effective management of metabolic health and bone disorders during pregnancy and lactation requires a nuanced approach to meet the dual needs of the mother and fetus (Fig. 1) [5].

Bone serves as a critical mineral reservoir that undergoes coordinated remodelling during pregnancy to support maternal–foetal mineral homeostasis [1,4]. Pregnancy represents an important period of physiological adaptation in mineral metabolism to meet the demands of the developing fetus [1]. The physiological requirement for calcium increases substantially in pregnancy, especially in the third trimester, driven by foetal skeletal mineralization [1]. In response, maternal physiology enhances calcium absorption in the intestine, primarily via upregulation of 1,25-dihydroxyvitamin D (calcitriol), leading to a two- to three-fold increase in intestinal calcium absorption [6]. Renal handling of calcium also adapts, although hormonal regulation is central to this adaptation. Parathyroid hormone-related peptide (PTHrP), produced by the placenta and breasts, rises significantly during pregnancy and lactation, contributing to maternal bone resorption and calcium mobilization. Oestrogen levels increase and exert a protective effect on the skeleton by inhibiting bone resorption, while endogenous calcitonin production may help buffer against excessive bone loss [7].

Despite these mechanisms, most clinical studies have shown increased bone turnover during pregnancy, with elevated biochemical markers of bone resorption [8] and, to a lesser extent, bone formation. These changes reflect the bone's active role in maternal adaptation, providing calcium through controlled and reversible skeletal remodelling. Understanding this dynamic interplay is essential for appreciating pregnancy as a unique window into bone physiology rather than solely a risk factor for osteoporosis [9].

While osteoporosis remains a central focus in maternal skeletal health, pregnancy can precipitate a range of musculoskeletal disorders that extend beyond bone fragility and fracture risk, and this has been discussed in a number of recent case reports [10,11]. Transient osteoporosis of pregnancy (TOP), often affecting the hip in the third trimester or early postpartum, presents with acute pain and functional limitation [12,13]. Though typically self-limiting, TOP can be difficult to diagnose and manage, particularly in settings with limited access to advanced imaging. Pregnancy- and lactation-associated osteoporosis (PLO) [10] is a rarer but clinically significant entity, characterized by fragility fractures, most commonly vertebral, that occur in late pregnancy or during lactation. The predisposing susceptibilities to PLO include high BMI, prior family history, poor diet, use of corticosteroids (e.g. for asthma or autoimmune diseases), or use of antiepileptic agents which can affect bone metabolism. The pathophysiology likely reflects exaggerated physiological bone resorption to meet foetal and neonatal calcium demands, particularly in women with low baseline bone mass, inadequate calcium and vitamin D intake, or prolonged exclusive breastfeeding [14]. Bone mineral density often improves after weaning in PLO, but full reversibility, especially regarding fracture risk and bone microarchitecture, cannot be assumed. Therefore, a period for spontaneous recovery should be allowed before considering targeted pharmacologic treatment, if clinically indicated.

In addition to osteoporosis, clinicians should be vigilant for other skeletal complications including stress fractures, postpartum sacral insufficiency fractures [15,16], and bone marrow oedema syndromes. These conditions are underdiagnosed and may be misattributed to common musculoskeletal complaints of pregnancy. Joint laxity, driven

https://doi.org/10.1016/j.crwh.2025.e00725
Received 3 June 2025; Received in revised form 4 June 2025; Accepted 16 June 2025
Available online 18 June 2025

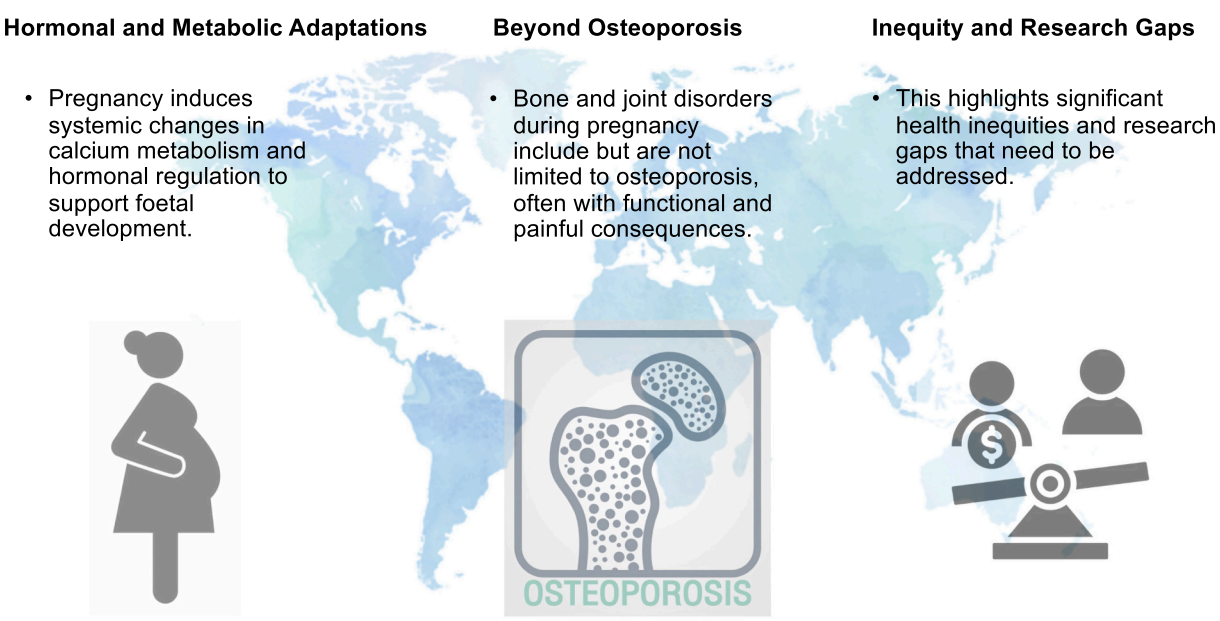

Fig. 1.. The relationship between hormonal and metabolic adaptations in pregnancy, bone and joint diseases such as osteoporosis in women, highlighting health inequities and research gaps.

by hormonal changes such as elevated relaxin, also contributes to musculoskeletal pain and increased risk of injury. Importantly, there is growing recognition that racial and ethnic disparities influence the prevalence, diagnosis, and outcomes of these bone disorders, although data specific to under-recognized conditions remain scarce and warrant further investigation [17]. Women from under-represented or marginalized backgrounds may experience differential access to care, lower rates of diagnosis, and variations in bone metabolism due to genetic and sociocultural factors [4,18]. Future research and clinical practice must therefore actively account for these disparities to improve equity in maternal bone health.

Pain during pregnancy, particularly musculoskeletal pain, is another common but often under-recognized component of maternal bone health and is difficult to treat [19]. It is also important to highlight under-recognized bone conditions that may either be pre-existing and worsen or present for the first time during pregnancy and lactation. These include rare but serious disorders such as Paget's disease, osteogenesis imperfecta, rickets and osteomalacia (nutritional as well as congenital and other acquired forms), and avascular necrosis (AVN) [5,20,21]. While data on these conditions in the context of pregnancy are limited, their occurrence may complicate maternal and foetal outcomes and they are often missed due to overlapping symptoms with more common musculoskeletal complaints. Increased clinical awareness and targeted screening protocols could significantly improve early recognition and management of these disorders [22,23].

There is a lack of large-scale, longitudinal studies examining the long-term skeletal consequences of pregnancy and lactation [24]. Most published data are restricted to case reports or very small cohorts, restricting our understanding of recovery trajectories and risk of future osteoporotic events. Current clinical care pathways rarely include bone health screening in young or postpartum women, even among those with known risk factors such as pre-existing low bone mass, eating disorders, vitamin D deficiency, autoimmune diseases, short interval between pregnancies, or prolonged exclusive breastfeeding. This oversight represents a significant gap and a missed opportunity for early intervention and risk mitigation.

Maternal bone health encompasses a spectrum of physiological adaptations and clinical challenges beyond osteoporosis. Recognizing pregnancy and lactation as periods of skeletal vulnerability and opportunity demands increased clinical awareness, multidisciplinary collaboration, and targeted research [24]. This includes addressing racial, ethnic, and geographic disparities in risk, diagnosis, and access to care. Advancing maternal musculoskeletal health requires integrating obstetric, rheumatologic, and endocrinologic expertise to inform prevention, early detection, and culturally relevant public health strategies. Conditions such as sacroiliac joint dysfunction, bone marrow oedema syndromes, and pregnancy-associated fractures can cause significant morbidity. Understanding and addressing these conditions is essential for optimizing function and quality of life during and after pregnancy. Effective treatment must consider the implications for the mother and fetus, optimizing non-pharmacological therapeutic options [25]. Fortunately, with early detection, the lost bone mass associated with pregnancy and lactation can often be regained, though the extent of recovery varies and requires careful monitoring.

Contributors

All authors have made substantial contributions to the manuscript. The authors collaborated to draft, revise and critically evaluate this editorial and approved the final submitted manuscript.

Provenance and peer review

This editorial was commissioned and not externally peer reviewed. Ali Mobasheri, an editorial board member of *Case Reports in Women's Health*, was not involved in editorial consideration of the manuscript and was blinded to the process.

Funding

The contribution of Jean-Yves Reginster to this article has been supported by the Distinguished Scientist Fellowship Program (DSFP) of the King Saud University, Riyadh, Kingdom of Saudi Arabia. Ali Mobasheri wishes to acknowledge the generous financial support of the Research Council of Lithuania/Lietuvos Mokslo Taryba, Research Council of Finland/Suomen Akatemia Profi 6, grant numbers 336449 and 351568, awarded to the University of Oulu. AM also acknowledges funding from Horizon Europe (PROTO-Advanced PeRsOnalized

Therapies for Osteoarthritis-TACKLING INFLAMMATION TO IMPROVE PATIENT OUTCOMES, grant agreement ID 101095635, https://cordis.europa.eu/project/id/101095635 and ENgineered CArtilage from Nose for the Treatment of Osteoarthritis (ENCANTO), grant agreement ID 101137315, https://cordis.europa.eu/project/id/101137315). AM also acknowledges support from the European Cooperation in Science and Technology COST Association Action CA21110 — Building an Open European Network on Osteoarthritis Research (NetwOArk); https://www.cost.eu/actions/CA21110/.

Conflict of interest statement

The authors declare that they have no conflict of interest regarding the publication of this editorial.

References

[1] C.S. Kovacs, Maternal mineral and bone metabolism during pregnancy, lactation, and post-weaning recovery, Physiol. Rev. 96 (2) (2016 Apr) 449–547.
[2] C.S. Kovacs, Calcium and phosphate metabolism and related disorders during pregnancy and lactation [Updated 2024 Oct 12], in: K.R. Feingold, S.F. Ahmed, B. Anawalt, et al. (Eds.), Endotext [Internet], MDText.com, Inc, South Dartmouth (MA), 2000. Available from: https://www.ncbi.nlm.nih.gov/books/NBK279173/.
[3] C.S. Kovacs, Calcium and bone metabolism during pregnancy and lactation, J. Mammary Gland Biol. Neoplasia 10 (2) (2005 Apr) 105–118.
[4] A. Capozzi, G. Scambia, S. Lello, Bone metabolism in pregnancy and lactation, Minerva Obstet. Gynecol. 73 (6) (2021 Dec) 697–703.
[5] M. Chandran, S.Y. Tse Tan, Disorders of bone and mineral metabolism in pregnancy and lactation: a case based clinical review, Osteoporos Sarcopenia 11 (1) (2025 Mar 19) 1–8.
[6] C.S. Kovacs, Calcium and bone metabolism disorders during pregnancy and lactation, Endocrinol. Metab. Clin. N. Am. 40 (4) (2011 Dec) 795–826.
[7] C.S. Kovacs, Bone development and mineral homeostasis in the fetus and neonate: roles of the calciotropic and phosphotropic hormones, Physiol. Rev. 94 (4) (2014 Oct) 1143–1218.
[8] E.M. Curtis, C. Parsons, K. Maslin, S. D'Angelo, R.J. Moon, S.R. Crozier, et al., Bone turnover in pregnancy, measured by urinary CTX, is influenced by vitamin D supplementation and is associated with maternal bone health: findings from the maternal vitamin D osteoporosis study (MAVIDOS) trial, Am. J. Clin. Nutr. 114 (5) (2021 Nov 8) 1600–1611.
[9] N. Gak, A. Abbara, W.S. Dhillo, R. Keen, A.N. Comninos, Current and future perspectives on pregnancy and lactation-associated osteoporosis, Front. Endocrinol. (Lausanne) 15 (2024 Dec 5) 1494965.
[10] M.F. Scioscia, M.B. Zanchetta, Recent insights into pregnancy and lactation-associated osteoporosis (PLO), Int. J. Women's Health (15) (2023 Aug 2) 1227–1238.
[11] F. Abelha Pereira, D.O. Miranda, J.M. Alvarenga, A.L. Correia, Pregnancy- and lactation-associated osteoporosis: a literature review based on a clinical case, Cureus 16 (11) (2024 Nov 2) e72889.
[12] A. Bhakta, Transient osteoporosis in the third trimester of pregnancy: a case report, Case Rep. Womens Health 34 (2022 Apr) e00400.
[13] E.V. Wright, A.Z. Naqvi, S. Syed, H. Zaw, Transient osteoporosis of the hip in pregnancy: the orthopaedic management of bilateral neck of femur fractures in the third trimester, BMJ Case Rep. 14 (3) (2021 Mar 1).
[14] E.C. O'Brien, A.A. Geraghty, M.T. Kilbane, M.J. McKenna, F.M. McAuliffe, Bone resorption and dietary calcium in pregnancy-a window to future maternal bone health, Osteoporos. Int. 32 (9) (2021 Sep) 1803–1814.
[15] C.X.B. Yan, L. Vautour, M.-H. Martin, Postpartum sacral insufficiency fractures, Skeletal Radiol. 45 (3) (2016 Mar) 413–417.
[16] G. Oztürk, D.G. Külcü, E. Aydoğ, Intrapartum sacral stress fracture due to pregnancy-related osteoporosis: a case report, Arch. Osteoporos. 8 (2013 Apr 25) 139.
[17] S.E. Noel, M.P. Santos, N.C. Wright, Racial and ethnic disparities in bone health and outcomes in the United States, J. Bone Miner. Res. 36 (10) (2021 Oct 7) 1881–1905.
[18] J. Wisser, I. Florio, M. Neff, V. König, R. Huch, A. Huch, et al., Changes in bone density and metabolism in pregnancy, Acta Obstet. Gynecol. Scand. 84 (4) (2005 Apr) 349–354.
[19] S. Kesikburun, Ü. Güzelküçük, U. Fidan, Y. Demir, A. Ergün, A.K. Tan, Musculoskeletal pain and symptoms in pregnancy: a descriptive study, Ther. Adv. Musculoskelet. Dis. 10 (12) (2018 Dec) 229–234.
[20] T.C. Key, E.O. Horger, Osteogenesis imperfecta as a complication of pregnancy, Obstet. Gynecol. 51 (1) (1978 Jan) 67–71.
[21] R. Rao, D. Cuthbertson, S.C.S. Nagamani, V.R. Sutton, B.H. Lee, J. Krischer, et al., Pregnancy in women with osteogenesis imperfecta: pregnancy characteristics, maternal, and neonatal outcomes, Am. J. Obstet. Gynecol. MFM 3 (4) (2021 Jul) 100362.
[22] A. Bhardwaj, K. Nagandla, Musculoskeletal symptoms and orthopaedic complications in pregnancy: pathophysiology, diagnostic approaches and modern management, Postgrad. Med. J. 90 (1066) (2014 Aug) 450–460.
[23] J. Borg-Stein, S.A. Dugan, Musculoskeletal disorders of pregnancy, delivery and postpartum, Phys. Med. Rehabil. Clin. N. Am. 18 (3) (2007 Aug) 459–476 (ix).
[24] E.M. Winter, A. Ireland, N.C. Butterfield, M. Haffner-Luntzer, M.N. Horcajada, A. G. Veldhuis-Vlug, et al., Pregnancy and lactation, a challenge for the skeleton, Endocr. Connect. 9 (6) (2020 Jun) R143–R157.
[25] F. Fiat, P.E. Merghes, A.D. Scurtu, B. Almajan Guta, C.A. Dehelean, N. Varan, et al., The main changes in pregnancy-therapeutic approach to musculoskeletal pain, Medicina (Kaunas) 58 (8) (2022 Aug 17).

Ali Mobasheri[a,b,c,d,*], Jean-Yves Reginster[e], Manju Chandran[f,g], Joyce McSwan[h]

[a] *Research Unit of Health Sciences and Technology, Faculty of Medicine, University of Oulu, Oulu, Finland*
[b] *Department of Regenerative Medicine, State Research Institute Centre for Innovative Medicine, Vilnius, Lithuania*
[c] *Department of Joint Surgery, First Affiliated Hospital of Sun Yat-Sen University, Guangzhou, China*
[d] *Image Analysis Group (IAG), London, United Kingdom*
[e] *Biochemistry Department, College of Science, King Saud University, 11451, Riyadh, Saudi Arabia*
[f] *Osteoporosis and Bone Metabolism Unit, Department of Endocrinology, Singapore General Hospital, Singapore*
[g] *DUKE NUS Medical School, Singapore*
[h] *PainWISE Pty Ltd, Gold Coast, Queensland, Australia*

[*] Corresponding author at: Musculoskeletal Biology, Research Unit of Health Sciences and Technology, Faculty of Medicine, University of Oulu, P.O. Box 5000, FI-90014 Oulu, Finland.
E-mail address: ali.mobasheri@oulu.fi (A. Mobasheri).