

Research Article

## Pregnancy-Related Hormonal Influences on the Musculoskeletal System, Lumbo-Pelvic Structures and Peripheral Joints: Some Practical Considerations for Manual Therapists

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**ABSTRACT:** The effects of maternal hormones upon the spine and pelvis, is not very well defined in the literature with evidence conflicting. Reports of hormonal effects (relaxin), appear to have mainly focused on the anterior cruciate, wrist ligaments, and anthropomorphic foot changes. Pregnancy hormonal influences upon peripheral joint capsulo-ligamentous structures, particular those of the lower limb, may also have indirect effects upon lumbo-pelvic structures by transferring ground reactive force (GRF) further up to kinetic chain.

**Objective:** Review the current evidence base to increase awareness among clinicians managing maternal pain populations of how hormonal influences may affect the musculoskeletal system.

**Method:** Literature published between 1982 and 2016 was reviewed through NCBI, Pubmed, Medline, and Ovid search engines. Additionally, a Google search of online media was conducted using the same terms.

**Conclusion:** Hormonal changes occurring during pregnancy may affect the female musculoskeletal system in a number of ways, with potential later in life consequence. Pregnancy associated lower limb changes such as maternal reduction of the plantar arch, may indirectly contribute to lower back pain, by causing redistribution of ground reactive force (GRF) centripetally, thereby increasing axial load upon already hormonally-compromised lumbo-pelvic structures. Future research is warranted to validate and verify hormonal influences upon musculoskeletal pain and dysfunction in this population group. Despite the popularity of manual management (chiropractic/osteopathy) for pregnancy back pain management, the evidence base for this is sparse. Though a review of available literature indicated manual therapies are probably both safe and effective means of management further research is imperative support clinical practice.

**Key Words:** Pregnancy, maternal, hormones, relaxin, back pain, ligaments, injury, spine, manipulation, chiropractic, osteopathy.

### INTRODUCTION

Hormonal changes occurring during pregnancy affect the female musculoskeletal system in a number of ways with potential later in life consequence. Though maternal hormonal changes serve to facilitate the parturition process, some alterations may predispose to the pathogenesis of degenerative disc disease, back pain, osteoporosis, DISH, musculoskeletal injury, or alter the course of preexisting conditions such as rheumatoid arthritis and joint hypermobility syndrome. [Li et al 2007, Sarli et al 2005, Sabino et al 2008, Lingren et al 2014]

Though adverse outcomes of maternal manual treatment (high velocity low amplitude thrusts) is reportedly of rare occurrence, [Cassidy et al 2009, Oliphant et al 2004], it is worthwhile to consider hormonal influences of the musculoskeletal system, particularly when managing peripartum back pain and planning peripheral and spinal joint manipulation in pregnancy.

### MATERNAL HORMONAL EFFECTS UPON LUMBO-PELVIC STRUCTURES

In order to facilitate fetal head descent, a complex interplay of hormonal, physiological BS biomechanical changes occur to relax pelvic ring ligamentous structures, which in turn,

may predispose to pregnancy-associated lumbar or pelvic ring pain. Though causation is multifactorial, this chapter will focus on the potential associations of maternal hormonal changes upon lower back, pelvic girdle and peripheral joint pain generation.

Reports of Pub Med database searches analyzing maternal back pain have concluded a typical presentation of pregnancy associated lower back or pelvic pain (PALP), presenting either as pelvic girdle pain between the posterior iliac crest and the gluteal fold or as a lumbar pain over and around the lumbar spine. [Katonis et al 2011]

Maternal LBP is highly prevalent, with statistical estimates suggesting that 50% of pregnant women will suffer some form of it, with one third of them experiencing severe pain affecting quality of life. Most are affected in their first pregnancy. [Wang et al 2004]

Younger maternal age and multiparity have also been identified as risk factors. [Mogren et al 2005]

Rodacki and colleagues reported that the spines of pregnant women with low back pain compress more after activity than pregnant women without back pain and those who are not pregnant, 4.57mm, 4.23mm, and 3.99 mm, respectively.

Pregnant women with low back pain also take longer to recover from activity related compression. [Rodacki et al 2003]

Anthropomorphic changes increasing lumbar axial spinal load also result in intervertebral discs compression fluid expulsion, with subsequent loss in disc height. [Bostford et al 1994]

These excessive axial compressive forces exerted upon the lumbar spine of women engaging in weight bearing activity while pregnant, results in increased LBP and longer recovery periods, in relation to women without LBP. [Sabino et al 2008]

Though symptoms usually spontaneously resolve post-partum, some females remain at higher risk of LBP in future pregnancies and later development of symptomatic lumbar degenerative disc disease. [Alexander et al 1993]

One study reviewing both LBP in pregnancy and post partum LBP still present 24 months, concluded that an onset of severe LBP early on in the index pregnancy, as a primary risk factor, with other predictors include prior episodic LBP when not pregnant, and inability to lose weight to pre-partum levels. However, PALBP does not seem to affect pregnancy outcomes. [To et al 2003]

Ossification of the ligamentum flavum [ossification of ligamentum flavum (OLF)], and the anterolateral spinal ligament as in diffuse idiopathic skeletal hyperostosis (DISH)] is frequently associated with myelopathy, radiculopathy, or both. Though OSL/DISH causation is related to a complex mix of genetic and environmental factors, a combination of sex hormone imbalance and local mechanical forces, may also mediate the pathogenesis of extra-spinal ligamentous ossification. [Li et al 2007]

It is normal to gain between 20 and 40 pounds during pregnancy, and weight gain in pregnancy has been associated with biomechanical changes predisposing to lower back pain. [Sadler 1996]

Weight gain in pregnancy however, does not appear to be directly linked to hormonal changes. Studies reviewing both maternal and fetal cord blood serum concentrations of estradiol, estriol, estrone, androstenedione, testosterone, dehydroepiandrosterone (DHEA) and DHEA sulfate at delivery, demonstrated no association of these hormone with pregnancy weight gain. [Faupel-Badger et al 2008]

However maternal hormonal changes have been associated with PALP pain. It has been reported that pelvic ligament laxity and associated pain begins around the 10-12 week of pregnancy. [Heckmen et al 1994]

As significant portion of women first experience pain during the first trimester, when mechanical changes do not yet play a significant role in the etiology of pain, some PALP pain may be secondary to hormonal changes rather than physical stresses. [Mogren 2005]

Relaxin hormones are insulin-like growth factor polypeptides which play an essential role in the metabolic processes of pregnancy, and have been associated with collagen remodeling. [Unemori et al 1990]

Elevations of relaxin levels affect metalloproteinases, altering ligament biomechanics through a collagenolytic effect. [Qin et al 1997]

Secretion from the corpus luteum and placenta commences early pregnancy, with relaxin levels increasing considerably during the first trimester, to remain steady until late pregnancy, before becoming serologically undetectable in the first few days post delivery. [Owens et al 2002]

While relaxin plays an important role in collagen catabolism of the pubic symphysis during gestation in lower mammals such as mice and rats [Samuel et al 1998], the role of this hormone on pubic symphysis of human is however unknown. [Hashem et al 2006, Wang et al 2009]

Though maternal serum levels do not necessarily reflect hormonal activity, [MacLennan 1991], some data proposes that relaxin concentrations increase as much as 10-fold during pregnancy, resulting in increased pliability of lumbo-pelvic ligaments, facet joint capsules, and the lumbar disc. Though some experimental studies take the view that relaxin linked to PALP pain and ligament laxity has not been proven, [Mens et al 2009], other studies define relaxin as a hormone responsible for maternal spino-pelvic ligamentous instability. [Sabino et al 2008]

Though some mammals require a high degree of pelvic relaxation for parturition, it is relatively less important in human females. However, it would appear that Scandinavian females on average, experience a much higher magnitude of pelvic girdle relaxation on average. [MacLennan 1991]

## **PREGNANCY & POST-PARTUM HORMONAL INFLUENCES ON SPINAL DISC DEGENERATION**

The etiology of lumbar disc disease is multifactorial, but in the literature describes a relationship between hormonal changes brought about by pregnancy and LBP. For most women, pain of discogenic origin, resolves spontaneously post-partum, although they remain at higher risk for increased LBP in future pregnancies and for the development of symptomatic degenerative disc disease (DDD) in later life. [Alexander et al 1993]

Biological effects of estrogen appear to influence disk degeneration, with studies demonstrating an estrogen-receptor  $\beta$  gene expression in human intervertebral disk cells, with estrogen enhancing cell proliferation in annulus cell cultures. [Gruber et al 2002]

The importance of estrogen's effects influencing a gender-related pathogenesis of DDD, is potentially demonstrated in a higher incidence and severity of disc degeneration in elderly women (post-menopausal) in comparison to age-matched men.

[Wang et al 2013, Manson et al 2006]

It is believed that axial compressive force transfer to the vertebral endplates increases as the bone mass of the vertebral body is decreased (vertebral osteoporosis), and this excessive mechanical overload could lead to endplate calcification and subsequent obstruction of disc nutrient-providing marrow contact channels, thus giving rise to disc degeneration. [Wang et al 2011]

MRI perfusion imaging in the elderly, has demonstrated a direct correlation of vertebral bone demineralization, and loss of bone marrow perfusion. [Griffith 2005]

Interestingly, female rats develop a predilection to DDD post ovariectomy. [Wang et al 2004]

There may also be a hormonal-smoking or smoking independent link to inhibition of end plate to disc nutrient transport, speculated to influence muscarinic receptor-regulated capillary blood flow.

[Holm et al 1988]

MRI studies of identical twins have also demonstrated that DDD is more severe in smoking siblings

Battié et al 1991]

Hormones also play a role in the vascular pathogenesis of DDD, by influencing the course of abdominal aortic and lumbar arterial atherosclerosis, and blood disorders such as sickle cell disease.

[Jones 1997, Kurunlahti et al 2001]

### **MATERNAL PERIPHERAL JOINT PAIN AND CAPSULOLIGAMENTOUS LAXITY**

A 2003 study which measured wrist flexion-extension laxity via goniometer, noted a significant correlation between elevations in maternal cortisol, with fifty-seven percent of test subjects reporting wrist joint pain during pregnancy. Though joint pain significantly increased in relation to serum estradiol and progesterone levels, there was not measurable change in joint laxity. [Marnach et al 2003]

However an earlier maternal joint laxity study relying on a hyperextensometer, demonstrated a significant increase in index finger joint laxity during the last trimester of pregnancy (0.02 greater than p greater than 0.01) over the readings from the same individuals after parturition. When primigravidae and multigravidae were compared, a highly significant increase in joint laxity was found in women having their second baby without change in further pregnancies. [Calguneri et al 1982]

It may also be that peripheral weight bearing joints may be particularly susceptible to hormonal related structural changes. For example, studies have reported increases in foot length, width, and volume during pregnancy. [Wetz et al 2006, Alvarez et al 1988]

Seagal and colleagues reported on pregnancy and multiparity as a risk factor for knee ligamentous laxity and post partum

permanent changes in foot length and arch drop leading to increased shoe size. Surprisingly, their work did not associate Beighton scoring, weight gain during pregnancy, and residual increased weight following pregnancy with these biomechanical changes. [Segal et al 2010, Segal et al 2013]

### **DISCUSSION**

Understanding the complex relationship between hormonal changes and maternal joint ligamentous laxity and LBP, lumbo pelvic, and peripheral joint pain remains a challenging undertaking. Voluminous research is also conflicting, with some studies relating higher relaxin levels to maternal pelvis-hip joint instability against controls [Saugstad 1991], while other studies found no hormonal pain-instability association. [Vollestad et al 2012]. However, research design and methodology may account for some of these data.

[Dehghan et al 2013]

Furthermore, a significant portion of women first experience pain during the first trimester, when mechanical changes such as spinal ligamentous laxity, do not yet play a significant role in the etiology of pain. [Mogren 2005]

This would suggest that elements of maternal LBP may be secondary to hormonal changes rather than simply biomechanical stressors. Hormonal changes during pregnancy may also influence the course of inflammation related back pain. Additionally, hormonal changes appear to have influences upon the severity of rheumatoid arthritis, as estrogen-containing oral contraceptives can attenuate its pathological course or onset, while alterations in prolactin levels during breast-feeding may increase the risk of RA onset. [Olsen et al 2002, Kanik et al 2000]

Despite these incongruencies, a practical understanding of the implications of hormonal effects upon the maternal musculoskeletal system is essential for safe and effective manual treatments.

[Olsen et al 2002, ]

Though data in conflictive, some studies have reported correlation between back pain and increased levels of relaxin hormones, which are produced during pregnancy [MacLennan et al 1986]

Although rare, pregnancy has also been associated with osteoporotic compression fractures and development of symptomatic in spinal tumors particularly vertebral hemangiomas, [Han 2010]

Formation and maintenance of the growing fetus's skeletal structures necessitate maternal hormonal and metabolic adjustments. Lactation places demands for calcium for maternal milk production subsequently lowering maternal calcium excretion and increasing bone resorption. [Sarli et al 2005]

Hemangiomas (benign vascular tumors of the vertebral bodies) are thought to be subject to lesion expansion via

hemodynamic and hormonal changes occurring during pregnancy, by which in rare cases may predispose to spinal pain and even severe cord compression. [Gupta et al 2014]

Sedentary females also increase their risk of back pain in comparison to those who maintain more active lifestyle. However, patients who have occupations described as 'mostly active' and 'physically demanding' also has a higher risk of developing pain during pregnancy suggesting that extremes of activity are probably not ideal either. [Sabino et al 2008]

Some females also associate post-partum LBP with epidural injections, yet studies linking epidural anesthesia to postpartum low back pain beyond one-day post delivery are inconsistent. [Macarthur et al 1995] Though hormonal changes and other factors are more likely to play a role in pregnancy-associated LBP, it is very common to blame the epidural when neurological complications occur. [Dahl 2001]

Though some studies have shown no association between relaxin and maternal lower back pain [Albert et al 1997], other studies have reported that raised maternal estradiol and progesterone levels are associated with increased peripheral joint pain without change in joint laxity. This data may perhaps point to a hormonally-mediated joint pain via a physiological mechanism independent of ligamentous laxity. These findings may apply to the spinal and pelvic structures as well. Variable designs and research methods (instrumental sensitivity to laxity detection) differences may be responsible for some of the conflicting data on this. That being said, estrogen and relaxin receptors are present in the human female ACL, and it would appear that elevated relaxin increases the incidence of anterior cruciate ligament (ACL) injury.

[Faryniarz et al 2006, Dragoo et al 2009]

A later prospective Dragoo study of elite female athletes reported players with increased serum relaxin levels had an increased risk of an ACL tear in comparison to controls [Dragoo et al 2011], in confirmation of prior research findings. [Schauberger et al 1996, Wojtys et al 2002]

Taking these findings, it may be that pregnancy does increase the risk of ligamentous injury.

[Dehghan et al 2013]

Hormonally-related changes in foot structure [[Wetz et al 2006], may also allow for the redistribution of ground reactive force transmission further up the kinetic chain. In theory, evolution to a more rigid and less shock-absorbing foot would be a contributory factor to the continuation of post-partum back pain with weight bearing activity.

There is a consensus that maternal lower back pain and pelvic pain are separate entities. [Noren et al 1997] This may be useful for purposes of classification, but it stands to reason that LBP and pelvic pain in pregnancy may share a common hormonal predisposition, and may also be subject to redistribution of ground reactive force from the above mentioned changes in foot structure. One may speculate that

associated lower limb biomechanical changes such as increased foot rigidity, may redistribute GRF further up the kinetic chain, with subsequent axial overload to already hormonally-compromised lumbo-pelvic ligament, creating a 'double whammy' of both tensile and compressive force contributions to maternal and peri-partum back pain.

The effects of maternal hormonal changes are obviously complex, affecting spinal ligamentous joint laxity, weight gain, and a shift in the center of gravity that leads to lumbar spine hyperlordosis and anterior tilting of the pelvis. Relaxin hormones play a key role in the regulating maternal hemodynamic and renovascular adaptations. [Teichman et al 2009], and these vascular changes may lead to compromised metabolic supply in the low back. [Casagrande et al 2015] Increased circulating blood volume coupled with hormone associated arteriovenous wall laxity, may lead to positional engorgement of pelvic vessels. Some evidence for this theory, may find support in a study correlating nocturnal pain in pregnancy with congestive heart failure. [Fast et al 1989]

Though spinal manipulation associated cerebral vertebral-basilar complications are extremely rare, [Oliphant 2004], Manual practitioners must also be aware of the hormonal interplay upon potentially increased manipulation risk factors associated with conditions such as preeclampsia/eclampsia, cesarean section, hypertension, chronic kidney disease, black race, pregnancy-related hematologic disorders, older age, migraines, gestational diabetes, primary (and also transient-reversible) hypercoagulable states, and smoking in pregnancy. [Miller et al 2016]

Hormonal influences upon PALP and peripheral joint pain do not occur in isolation, but are one of many interrelated variables involving biomechanics, trauma, metabolism, and pre-existing genetic and degenerative factors. [Kanakaris et al 2011]

Manipulative therapies such as chiropractic, appear to be a safe and effective means of managing back pain in pregnancy. [Borggren 2007]. However optimal management may best be achieved by taking a multi-disciplinary approach, including other modalities such as podiatry, physiotherapy, manual treatment, and orthopaedic medical support.

Improved understanding of the hormonally influenced interplay between maternal spinal, pelvic and peripheral joint pain and biomechanics are topics for further research, which may provide the key to refining and coordinating existing multi-disciplinary treatments, and also evolving new approaches for management.

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