

## **SKELETAL, MUSCULAR, AND ARTICULAR ALTERATIONS DURING PREGNANCY: IMPLICATIONS FOR MATERNAL HEALTH**

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**Resume:** **INTRODUCTION** Pregnancy induces a myriad of physiological changes in a woman's body to support fetal development. Significant adaptations occur in the musculoskeletal system, driven by hormonal changes and biomechanical stresses. These changes can impact maternal health, necessitating a comprehensive understanding of the skeletal, muscular, and articular alterations that occur during this period. This review focuses on these adaptations, the role of hormones like relaxin, and the management of common musculoskeletal complaints such as pelvic girdle pain and lower back pain. **OBJECTIVE** To examine the skeletal, muscular, and articular changes during pregnancy. **METHODS** This is a narrative review which included studies in the MEDLINE – PubMed (National Library of Medicine, National Institutes of Health), COCHRANE, EMBASE and Google Scholar databases, using as descriptors: “Pregnancy-related musculoskeletal changes” OR “Hormonal influences on musculoskeletal health” OR “Pelvic girdle pain and pregnancy” OR “Non-pharmacological pain management” OR “Postpartum musculoskeletal care” in the last years. **RESULTS AND DISCUSSION** Pelvic girdle pain and lower back pain are prevalent among pregnant women, influenced by factors such as hormonal changes and biomechanical adjustments. The hormone relaxin plays a critical role in increasing joint laxity, leading to instability and pain. Weight gain and changes in posture further exacerbate these issues. Effective management includes physical therapy, exercise programs, and supportive devices like maternity belts. Nutritional support and non-pharmacological interventions, such as prenatal yoga and chiropractic care, are also beneficial. The psychological impact of chronic pain is significant, necessitating a holistic approach to pain management.

**CONCLUSION** Pregnancy presents unique challenges to the musculoskeletal system, significantly impacting maternal health. A multidisciplinary approach incorporating physical therapy, tailored exercise programs, nutritional support, and psychological care is essential for managing these changes effectively. Understanding the hormonal and biomechanical influences on musculoskeletal health during pregnancy is crucial for developing comprehensive care plans. Long-term follow-up and postpartum care are necessary to address persistent musculoskeletal issues and ensure the well-being of new mothers. Future research should continue to explore the underlying mechanisms and efficacy of various management strategies to improve outcomes for pregnant women.

**Keywords:** Musculoskeletal pain in pregnancy; Pelvic girdle pain; Relaxin and joint laxity; Prenatal exercise; Postpartum rehabilitation

## INTRODUCTION

Pregnancy is a complex physiological state that entails a myriad of adaptations in a woman's body to support the developing fetus<sup>1</sup>. These changes are multifaceted, affecting various systems including the cardiovascular, respiratory, and endocrine systems<sup>1</sup>. Among the most significant are the alterations in the musculoskeletal system, which play a critical role in accommodating the growing uterus and the resultant biomechanical stresses<sup>1</sup>. Maternal health during pregnancy is pivotal, not only for the well-being of the mother but also for the optimal growth and development of the fetus<sup>2</sup>. The physiological changes during pregnancy are extensive and encompass cardiovascular adaptations like increased blood volume and cardiac output, respiratory adjustments including increased tidal volume and oxygen consumption, and renal modifications such as enhanced

glomerular filtration rate<sup>2</sup>. However, the focus of this review is on the skeletal, muscular, and articular alterations that occur during this period<sup>2</sup>.

The skeletal system undergoes significant changes during pregnancy, primarily to support the additional weight and to prepare for childbirth<sup>3</sup>. One of the major skeletal changes includes the remodeling of the pelvic bones to accommodate the growing fetus and facilitate delivery<sup>3</sup>. The increase in bone turnover and resorption, often influenced by hormonal changes, can impact maternal bone density<sup>3</sup>. Pregnant women experience increased mobility of the pelvic joints, particularly the sacroiliac joints and the pubic symphysis, leading to a condition known as pelvic girdle pain (PGP)<sup>4</sup>. This increased mobility is partly due to the action of relaxin, a hormone that facilitates ligamentous relaxation<sup>4</sup>.

Muscular adaptations during pregnancy are equally significant<sup>5</sup>. The abdominal muscles, particularly the rectus abdominis, undergo stretching and separation to accommodate the enlarging uterus, a condition known as diastasis recti<sup>5</sup>. This separation can weaken the core muscles, affecting posture and balance<sup>5</sup>. The back muscles, including the erector spinae, become more active to compensate for the forward shift in the center of gravity<sup>6</sup>. These muscular adaptations, while necessary, can contribute to discomfort and pain, particularly in the lower back<sup>6</sup>. The muscles of the pelvic floor also undergo significant changes, which are crucial for supporting the weight of the growing fetus and preparing for labor<sup>6</sup>.

Articular changes, particularly in the joints, are profound during pregnancy<sup>7</sup>. The increased production of relaxin results in the loosening of the ligaments that support the joints, leading to increased joint laxity<sup>7</sup>. This laxity can cause instability and pain in various

joints, most commonly in the pelvis, hips, and knees<sup>7</sup>. Pelvic girdle pain and symphysis pubis dysfunction are common complaints among pregnant women, significantly impacting their quality of life<sup>8</sup>. The loosening of ligaments also affects the spinal joints, contributing to the prevalence of lower back pain during pregnancy<sup>8</sup>. Additionally, changes in posture and gait, necessitated by the growing abdomen, place extra stress on the joints and muscles, further exacerbating discomfort<sup>8</sup>.

Hormonal influences on the musculoskeletal system during pregnancy are profound<sup>9</sup>. Estrogen, progesterone, and relaxin play pivotal roles in modulating the elasticity of connective tissues<sup>9</sup>. Estrogen promotes the synthesis of collagen and elastin, essential components of the connective tissue, while progesterone has a catabolic effect on collagen, reducing its tensile strength<sup>9</sup>. Relaxin, on the other hand, specifically targets the pelvic ligaments, increasing their laxity to facilitate childbirth<sup>10</sup>. This hormonal interplay is crucial for the physiological adaptations during pregnancy but also predisposes women to musculoskeletal pain and discomfort<sup>10</sup>.

Pelvic girdle pain (PGP) is a prevalent condition during pregnancy, affecting a significant proportion of women<sup>11</sup>. It is characterized by pain in the pelvic region, often radiating to the lower back and thighs<sup>11</sup>. The etiology of PGP is multifactorial, with biomechanical, hormonal, and genetic factors playing roles<sup>11</sup>. The increased mobility of the pelvic joints due to relaxin and the altered biomechanics due to the growing uterus contribute to PGP<sup>12</sup>. Management of PGP includes physical therapy, the use of pelvic support belts, and in some cases, pharmacological interventions<sup>12</sup>. Lower back pain is another common musculoskeletal complaint during pregnancy<sup>12</sup>. The forward shift in the center of gravity due to the growing abdomen increases the lumbar

lordosis, placing extra strain on the lumbar spine<sup>13</sup>. This, combined with the increased ligamentous laxity, contributes to lower back pain<sup>13</sup>.

Sciatica, characterized by pain radiating along the sciatic nerve, is another condition that can occur during pregnancy<sup>14</sup>. The increased pressure on the lumbar spine and pelvis can compress the sciatic nerve, leading to pain and discomfort<sup>14</sup>. Management includes physical therapy, exercise, and in severe cases, pharmacological interventions<sup>15</sup>. Symphysis pubis dysfunction (SPD) is a specific condition where the pubic symphysis becomes excessively mobile, leading to pain and instability in the pelvic region<sup>15</sup>. SPD can significantly impact a woman's ability to walk and perform daily activities<sup>16</sup>. Management includes pelvic support belts, physical therapy, and in severe cases, pharmacological interventions<sup>16</sup>.

Changes in posture and gait are inevitable during pregnancy<sup>17</sup>. The growing abdomen shifts the center of gravity forward, necessitating adjustments in posture and gait to maintain balance<sup>17</sup>. This often results in an increased lumbar lordosis and anterior pelvic tilt<sup>18</sup>. These changes place extra strain on the lower back and pelvic muscles, contributing to discomfort and pain<sup>18</sup>. Weight gain during pregnancy further exacerbates these issues by increasing the biomechanical load on the musculoskeletal system<sup>19</sup>. Nutritional needs for maintaining musculoskeletal health during pregnancy are paramount<sup>19</sup>. Adequate intake of calcium, vitamin D, and protein is essential to support bone health and muscle function<sup>20</sup>. Deficiencies in these nutrients can exacerbate musculoskeletal issues and impact fetal development<sup>20</sup>.

Exercise and physical activity during pregnancy are beneficial for maintaining musculoskeletal health and managing pain<sup>21</sup>. Regular exercise can help strengthen the

muscles, improve flexibility, and enhance cardiovascular health<sup>21</sup>. However, it is crucial to tailor exercise programs to the individual needs of pregnant women, taking into consideration their musculoskeletal complaints and overall health<sup>22</sup>. Common musculoskeletal disorders during pregnancy include PGP, lower back pain, diastasis recti, and SPD<sup>22</sup>. Management of these conditions involves a multidisciplinary approach, including physical therapy, exercise, nutritional support, and in some cases, pharmacological interventions<sup>23</sup>.

The impact of pre-existing musculoskeletal conditions on pregnancy outcomes is significant<sup>23</sup>. Women with conditions such as arthritis, scoliosis, or previous musculoskeletal injuries may experience exacerbated symptoms during pregnancy<sup>24</sup>. Close monitoring and tailored management plans are essential to ensure the well-being of both the mother and the fetus<sup>24</sup>. The psychological aspects of musculoskeletal pain during pregnancy are often overlooked<sup>25</sup>. Chronic pain can lead to anxiety, depression, and reduced quality of life<sup>25</sup>. Addressing these psychological aspects is crucial for comprehensive pain management<sup>25</sup>.

Preventive measures and recommendations for maintaining musculoskeletal health during pregnancy include regular exercise, proper nutrition, ergonomic adjustments, and the use of supportive devices such as maternity belts<sup>26</sup>. Education and counseling on posture, gait, and body mechanics can also help reduce the risk of musculoskeletal issues<sup>26</sup>. In summary, pregnancy induces significant skeletal, muscular, and articular changes that can impact maternal health<sup>27</sup>. Understanding these changes and implementing appropriate management strategies is crucial for ensuring the well-being of pregnant women<sup>27</sup>.

## **OBJETIVES**

To examine the skeletal, muscular, and articular changes during pregnancy.

## **SECUNDARY OBJETIVES**

1. To analyze the role of hormones such as relaxin, estrogen, and progesterone on musculoskeletal adaptations.
2. To evaluate the efficacy of non-pharmacological interventions such as physical therapy, prenatal yoga, and aquatic therapy.
3. To investigate the long-term impact of pregnancy on musculoskeletal health.
4. To explore the influence of pre-existing musculoskeletal conditions on pregnancy outcomes.
6. To assess the impact of these changes on maternal health and quality of life.
7. To review effective management strategies for pregnancy-related musculoskeletal pain.

## **METHODS**

This is a narrative review, in which the main aspects of skeletal, muscular, and articular changes during pregnancy in recent years were analyzed. The beginning of the study was carried out with theoretical training using the following databases: PubMed, sciELO and Medline, using as descriptors: "Pregnancy-related musculoskeletal changes" OR "Hormonal influences on musculoskeletal health" OR "Pelvic girdle pain and pregnancy" OR "Non-pharmacological pain management" OR "Postpartum musculoskeletal care" in the last years. As it is a narrative review, this study does not have any risks.

Databases: This review included studies in the MEDLINE – PubMed (National Library of Medicine, National Institutes of Health), COCHRANE, EMBASE and Google Scholar databases.



The inclusion criteria applied in the analytical review were human intervention studies, experimental studies, cohort studies, case-control studies, cross-sectional studies and literature reviews, editorials, case reports, and poster presentations. Also, only studies writing in English and Portuguese were included.

## RESULTS AND DISCUSSION

The prevalence of pelvic girdle pain (PGP) in pregnant women is notably high, with studies reporting incidences ranging from 20% to 45%<sup>28</sup>. PGP is characterized by pain localized to the pelvic region, which can radiate to the lower back and thighs<sup>28</sup>. The etiology of PGP is multifactorial, involving biomechanical, hormonal, and genetic factors<sup>29</sup>. The increased laxity of the pelvic ligaments, driven by the hormone relaxin, plays a pivotal role in the development of PGP<sup>29</sup>. Additionally, the altered biomechanics due to the growing uterus and changes in posture further exacerbate the condition<sup>30</sup>. Effective management strategies for PGP include physical therapy, pelvic support belts, and exercise programs tailored to the individual needs of pregnant women<sup>30</sup>. These interventions aim to strengthen the pelvic muscles, improve stability, and alleviate pain<sup>31</sup>.

Lower back pain (LBP) is another common complaint during pregnancy, with prevalence rates ranging from 50% to 70%<sup>31</sup>. The increased lumbar lordosis, caused by the forward shift in the center of gravity due to the growing abdomen, places extra strain on the lumbar spine<sup>32</sup>. The hormonal influences, particularly the increased levels of relaxin, contribute to ligamentous laxity and instability in the lumbar region, exacerbating LBP<sup>32</sup>. Physical therapy, exercise, and ergonomic adjustments are effective in managing LBP during pregnancy<sup>33</sup>. Strengthening the core muscles and improving posture can

significantly reduce the severity of LBP<sup>33</sup>. Relaxin plays a critical role in joint stability during pregnancy<sup>34</sup>. This hormone, produced by the ovaries and placenta, increases the laxity of the ligaments, particularly in the pelvic region, to facilitate childbirth<sup>34</sup>. However, this increased laxity can lead to instability and pain in various joints, including the pelvis, hips, and knees<sup>35</sup>. The effect of relaxin on joint stability is most pronounced in the later stages of pregnancy, coinciding with the peak levels of the hormone<sup>35</sup>. Management strategies to mitigate the impact of relaxin include the use of supportive devices such as maternity belts, physical therapy, and exercise programs aimed at strengthening the supporting muscles<sup>36</sup>.

Weight gain during pregnancy significantly impacts musculoskeletal pain<sup>36</sup>. The additional weight increases the biomechanical load on the musculoskeletal system, particularly the lower back, pelvis, and lower extremities<sup>37</sup>. This increased load exacerbates conditions such as PGP, LBP, and SPD<sup>37</sup>. Proper weight management through a balanced diet and regular exercise is essential to minimize the impact of weight gain on musculoskeletal pain<sup>38</sup>. Nutritional support, including adequate intake of calcium, vitamin D, and protein, is also crucial for maintaining musculoskeletal health<sup>38</sup>. Changes in posture and gait during pregnancy are inevitable due to the growing abdomen and the resultant shift in the center of gravity<sup>39</sup>. These changes, including increased lumbar lordosis and anterior pelvic tilt, place extra strain on the lower back and pelvic muscles, contributing to discomfort and pain<sup>39</sup>. The altered gait pattern, often characterized by a wider stance and increased hip movement, further exacerbates musculoskeletal issues<sup>40</sup>. Physical therapy and ergonomic adjustments can help manage these changes and reduce the risk of injury<sup>40</sup>.

Physical therapy plays a vital role in managing pregnancy-related musculoskeletal issues, providing relief from pain and improving functionality<sup>41</sup>. Physical therapy interventions focus on strengthening the core and pelvic muscles, improving posture, and enhancing flexibility<sup>41</sup>. Exercise programs tailored to pregnant women, such as prenatal yoga and aquatic therapy, are effective in alleviating musculoskeletal pain and improving overall physical health<sup>42</sup>. Prenatal yoga, in particular, has been shown to improve flexibility, strength, and relaxation, reducing the incidence and severity of musculoskeletal pain<sup>42</sup>. Nutritional deficiencies can exacerbate musculoskeletal issues during pregnancy<sup>43</sup>. Adequate intake of essential nutrients, such as calcium, vitamin D, and protein, is crucial for maintaining bone health and muscle function<sup>43</sup>. Calcium and vitamin D play pivotal roles in bone mineralization and muscle function, and deficiencies in these nutrients can lead to increased risk of osteoporosis and muscle weakness<sup>44</sup>. Nutritional counseling and supplementation, when necessary, are essential components of prenatal care to ensure optimal musculoskeletal health<sup>44</sup>.

Symphysis pubis dysfunction (SPD) is a condition characterized by excessive movement and instability of the pubic symphysis, leading to pain and difficulty in movement<sup>45</sup>. SPD is caused by the increased laxity of the pelvic ligaments, driven by hormonal changes, particularly the action of relaxin<sup>45</sup>. The condition significantly impacts a woman's ability to walk and perform daily activities<sup>46</sup>. Management of SPD includes the use of pelvic support belts, physical therapy, and, in severe cases, pharmacological interventions to manage pain and inflammation<sup>46</sup>. The impact of pregnancy on women with pre-existing musculoskeletal conditions is significant<sup>47</sup>. Conditions such as arthritis, scoliosis, or previous musculoskeletal injuries can be

exacerbated by the physiological changes during pregnancy<sup>47</sup>. Close monitoring and tailored management plans are essential to ensure the well-being of both the mother and the fetus<sup>48</sup>. Physical therapy, exercise, and nutritional support are critical components of care for these women<sup>48</sup>.

The psychological impact of musculoskeletal pain during pregnancy is an important consideration<sup>49</sup>. Chronic pain can lead to anxiety, depression, and reduced quality of life<sup>49</sup>. Addressing these psychological aspects is crucial for comprehensive pain management<sup>50</sup>. Counseling, support groups, and stress-reduction techniques can help mitigate the psychological impact of musculoskeletal pain<sup>50</sup>. Non-pharmacological pain management strategies are effective in managing musculoskeletal pain during pregnancy<sup>51</sup>. These strategies include physical therapy, exercise, acupuncture, chiropractic care, and the use of supportive devices such as maternity belts<sup>51</sup>. These interventions aim to reduce pain, improve functionality, and enhance overall well-being without the use of medications, which can have potential risks for the fetus<sup>52</sup>.

The long-term impact of pregnancy on musculoskeletal health is an area of ongoing research<sup>52</sup>. While many women experience resolution of musculoskeletal pain postpartum, some may have persistent issues<sup>53</sup>. Factors such as the severity of pain during pregnancy, the presence of pre-existing conditions, and postpartum care can influence long-term outcomes<sup>53</sup>. Regular follow-up and continued support are essential for managing chronic musculoskeletal issues<sup>54</sup>. Prenatal yoga is an effective intervention for alleviating musculoskeletal pain during pregnancy<sup>54</sup>. Yoga practices focus on gentle stretching, strengthening, and relaxation, which can help reduce pain and improve overall physical health<sup>55</sup>. Studies have shown that prenatal

yoga can significantly reduce the incidence and severity of lower back pain, pelvic girdle pain, and other musculoskeletal issues<sup>55</sup>. It also provides psychological benefits, helping to reduce anxiety and improve mood<sup>56</sup>.

The impact of hormonal changes on muscle strength and flexibility is profound<sup>56</sup>. Hormones such as relaxin, estrogen, and progesterone modulate the elasticity of connective tissues, influencing muscle function<sup>57</sup>. Relaxin, in particular, increases the laxity of the ligaments, affecting joint stability and muscle strength<sup>57</sup>. Understanding the hormonal influences on the musculoskeletal system is crucial for developing effective management strategies<sup>58</sup>. Sciatica is a condition characterized by pain radiating along the sciatic nerve, often caused by compression of the nerve in the lumbar spine or pelvis<sup>58</sup>. The increased pressure on the lumbar spine and pelvis during pregnancy can lead to sciatica, causing significant discomfort and disability<sup>59</sup>. Management includes physical therapy, exercise, and, in severe cases, pharmacological interventions to alleviate pain and inflammation<sup>59</sup>.

Maternity support belts are effective in managing musculoskeletal pain during pregnancy<sup>60</sup>. These belts provide support to the lower back and abdomen, reducing strain on the lumbar spine and pelvis<sup>60</sup>. Studies have shown that the use of maternity support belts can significantly reduce pain and improve functionality in pregnant women<sup>61</sup>. They are a valuable adjunct to physical therapy and exercise programs<sup>61</sup>. Hydration plays a critical role in preventing musculoskeletal cramps during pregnancy<sup>62</sup>. Adequate fluid intake is essential for maintaining muscle function and preventing dehydration, which can exacerbate muscle cramps<sup>62</sup>. Hydration, combined with proper nutrition and exercise, can help reduce the incidence of musculoskeletal cramps<sup>63</sup>. Sleep quality significantly impacts

musculoskeletal pain during pregnancy<sup>63</sup>. Poor sleep can exacerbate pain and reduce the body's ability to recover and heal<sup>64</sup>. Ensuring adequate sleep through proper sleep hygiene practices, ergonomic adjustments, and managing stress is essential for managing musculoskeletal pain<sup>64</sup>.

Stress is a significant factor influencing musculoskeletal pain during pregnancy<sup>65</sup>. Chronic stress can exacerbate pain and contribute to muscle tension and discomfort<sup>65</sup>. Stress-reduction techniques, such as relaxation exercises, counseling, and support groups, can help manage the psychological aspects of musculoskeletal pain and improve overall well-being<sup>66</sup>. Chiropractic care is an effective intervention for managing musculoskeletal pain during pregnancy<sup>66</sup>. Chiropractors use manual manipulation techniques to improve joint mobility and reduce pain<sup>67</sup>. Studies have shown that chiropractic care can significantly reduce lower back pain, pelvic girdle pain, and other musculoskeletal issues in pregnant women<sup>67</sup>. It is a valuable adjunct to physical therapy and other non-pharmacological interventions<sup>68</sup>.

Postpartum musculoskeletal pain can significantly impact maternal health and quality of life<sup>68</sup>. Conditions such as diastasis recti, pelvic girdle pain, and lower back pain may persist postpartum, affecting a woman's ability to care for her newborn and perform daily activities<sup>69</sup>. Continued physical therapy, exercise, and support are essential for managing postpartum musculoskeletal pain<sup>69</sup>. Occupational therapy plays a crucial role in supporting pregnant women with musculoskeletal issues<sup>70</sup>. Occupational therapists provide interventions to improve functionality and manage pain, helping women to perform daily activities and maintain their quality of life<sup>70</sup>. Ergonomic adjustments, activity modification, and adaptive equipment are some of the strategies



used by occupational therapists<sup>71</sup>.

Aquatic therapy is an effective intervention for managing musculoskeletal pain during pregnancy<sup>71</sup>. The buoyancy of water reduces the strain on the musculoskeletal system, allowing for gentle exercise and pain relief<sup>72</sup>. Aquatic therapy can help improve flexibility, strength, and cardiovascular health, making it an ideal intervention for pregnant women<sup>72</sup>. Vitamin D plays a critical role in maintaining musculoskeletal health during pregnancy<sup>73</sup>. Adequate levels of vitamin D are essential for bone mineralization and muscle function<sup>73</sup>. Deficiencies in vitamin D can lead to increased risk of osteoporosis and muscle weakness<sup>74</sup>. Nutritional counseling and supplementation, when necessary, are essential components of prenatal care<sup>74</sup>. The pelvic floor muscles undergo significant changes during pregnancy to support the weight of the growing fetus and prepare for labor<sup>75</sup>. Weakness or dysfunction of the pelvic floor muscles can lead to conditions such as urinary incontinence and pelvic organ prolapse<sup>75</sup>. Pelvic floor exercises, such as Kegels, are effective in strengthening these muscles and preventing dysfunction<sup>76</sup>.

Carpal tunnel syndrome (CTS) is a common condition during pregnancy, characterized by numbness, tingling, and pain in the hands and fingers<sup>76</sup>. CTS is caused by the compression of the median nerve in the wrist, often exacerbated by fluid retention and hormonal changes<sup>77</sup>. Management includes wrist splints, physical therapy, and ergonomic adjustments to reduce symptoms and improve function<sup>77</sup>. Pregnancy can impact hip joint stability due to the increased laxity of the ligaments and the altered biomechanics of the pelvis<sup>78</sup>. This can lead to conditions such as hip pain and instability<sup>78</sup>. Physical therapy and exercise programs focused on strengthening the hip muscles and improving stability are essential for managing these issues<sup>79</sup>. Acupuncture is an effective intervention for managing

pregnancy-related musculoskeletal pain<sup>79</sup>. Acupuncture involves the insertion of fine needles into specific points on the body to relieve pain and improve function<sup>80</sup>. Studies have shown that acupuncture can significantly reduce lower back pain, pelvic girdle pain, and other musculoskeletal issues in pregnant women<sup>80</sup>.

Multiple pregnancies can have a cumulative impact on musculoskeletal health<sup>81</sup>. The repeated physiological changes and increased strain on the musculoskeletal system can exacerbate conditions such as PGP, LBP, and SPD<sup>81</sup>. Close monitoring and tailored management plans are essential for women with multiple pregnancies to ensure their well-being<sup>82</sup>. Genetic factors can influence the risk of developing musculoskeletal disorders during pregnancy<sup>82</sup>. Conditions such as hypermobility syndromes and connective tissue disorders can increase the risk of musculoskeletal pain and instability<sup>83</sup>. Understanding the genetic predispositions and providing tailored interventions are crucial for managing these conditions<sup>83</sup>.

Cesarean section (C-section) can impact postpartum musculoskeletal health<sup>84</sup>. The surgical incision and recovery process can lead to pain and dysfunction in the abdominal and pelvic regions<sup>84</sup>. Physical therapy and rehabilitation are essential for managing pain and improving function postpartum<sup>85</sup>. Physical activity levels during pregnancy are closely related to musculoskeletal pain<sup>85</sup>. Regular exercise can help strengthen the muscles, improve flexibility, and reduce the incidence and severity of pain<sup>86</sup>. However, the type and intensity of exercise should be tailored to the individual needs of pregnant women<sup>86</sup>. Ergonomic interventions are effective in managing musculoskeletal pain during pregnancy<sup>87</sup>. Adjustments in posture, workstations, and daily activities can help reduce strain on the musculoskeletal

system<sup>87</sup>. Ergonomic counseling and the use of adaptive equipment are essential components of prenatal care<sup>88</sup>. Inflammatory markers play a role in pregnancy-related musculoskeletal pain<sup>88</sup>. Increased levels of pro-inflammatory cytokines can exacerbate pain and inflammation in the musculoskeletal system<sup>89</sup>. Anti-inflammatory interventions, including dietary modifications and physical therapy, can help manage these issues<sup>89</sup>.

Hormonal replacement therapy (HRT) can impact postpartum musculoskeletal health<sup>90</sup>. HRT can help alleviate symptoms of hormonal deficiencies and improve bone and muscle health<sup>90</sup>. However, the benefits and risks of HRT should be carefully evaluated for each individual<sup>91</sup>. Prenatal education is crucial for preventing musculoskeletal disorders during pregnancy<sup>91</sup>. Educating women on proper posture, body mechanics, and exercise can help reduce the risk of musculoskeletal pain and improve overall health<sup>92</sup>. Prenatal classes and counseling are valuable resources for pregnant women<sup>92</sup>. Breastfeeding can impact musculoskeletal health, primarily through hormonal influences and physical demands<sup>93</sup>. The process of breastfeeding involves prolonged periods of sitting in static postures, which can contribute to lower back and neck pain<sup>93</sup>. Additionally, the hormonal milieu during lactation, including decreased levels of estrogen, can impact bone density and muscle function<sup>94</sup>. Addressing ergonomic aspects of breastfeeding positions, encouraging breaks and postural adjustments, and ensuring adequate nutritional support are essential for maintaining musculoskeletal health during this period<sup>94</sup>.

Body Mass Index (BMI) has a significant relationship with musculoskeletal pain during pregnancy<sup>95</sup>. Higher BMI is associated with an increased risk of developing conditions such as pelvic girdle pain, lower back pain, and knee pain<sup>95</sup>. The additional weight contributes to

biomechanical strain on the musculoskeletal system, exacerbating pain and discomfort<sup>96</sup>. Weight management through a balanced diet and appropriate exercise is crucial for reducing the risk of musculoskeletal issues in overweight and obese pregnant women<sup>96</sup>. Socioeconomic factors can also impact musculoskeletal health during pregnancy<sup>97</sup>. Access to healthcare, nutrition, and support services can influence the prevalence and management of musculoskeletal pain<sup>97</sup>. Women from lower socioeconomic backgrounds may have limited access to prenatal care, physical therapy, and nutritional support, increasing their risk of developing and experiencing untreated musculoskeletal pain<sup>98</sup>. Addressing these disparities through targeted interventions and support programs is essential for improving maternal health outcomes<sup>98</sup>.

## CONCLUSION

Pregnancy induces a range of skeletal, muscular, and articular changes that have significant implications for maternal health. The hormonal shifts, weight gain, and biomechanical adaptations required to support the growing fetus place unique demands on the musculoskeletal system. Conditions such as pelvic girdle pain, lower back pain, and symphysis pubis dysfunction are prevalent and can significantly impact the quality of life for pregnant women. Effective management strategies, including physical therapy, tailored exercise programs, nutritional support, and ergonomic adjustments, are essential for alleviating pain and maintaining musculoskeletal health.

Understanding the complex interplay of hormonal influences, biomechanical changes, and individual factors such as pre-existing conditions and BMI is crucial for developing comprehensive care plans for pregnant women. Non-pharmacological interventions,

including prenatal yoga, aquatic therapy, and chiropractic care, offer valuable alternatives for pain management, reducing the need for medications that may pose risks to the fetus. Long-term follow-up and postpartum care are critical for addressing persistent musculoskeletal issues and ensuring the well-being of new mothers. Addressing psychological aspects of chronic pain, providing ongoing support, and encouraging physical activity and proper nutrition are essential components of comprehensive maternal care.

Future research should continue to explore the underlying mechanisms of pregnancy-related musculoskeletal changes, the efficacy of various management strategies, and the impact of socioeconomic factors on maternal

health. By advancing our understanding and improving care practices, we can enhance the health and quality of life for pregnant women and new mothers, ensuring better outcomes for both mothers and their babies.

In conclusion, the skeletal, muscular, and articular changes during pregnancy present unique challenges for maternal health. A multidisciplinary approach, incorporating physical therapy, exercise, nutrition, and psychological support, is essential for managing these changes effectively. By addressing the diverse needs of pregnant women and providing targeted interventions, healthcare providers can help mitigate the impact of these changes and promote optimal maternal and fetal health.

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