

# Maternal physiological changes in pregnancy

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**Maternal physiological changes in pregnancy** are the normal adaptations that a woman undergoes during [pregnancy](#) to better accommodate the [embryo](#) or [fetus](#). They are [physiological](#) changes, that is, they are entirely normal, and include [cardiovascular](#), [hematologic](#), [metabolic](#), [renal](#) and [respiratory](#) changes that become very important in the event of complications.

## Hormonal

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Pregnant women experience numerous adjustments in their [endocrine system](#). Levels of progesterone and estrogens rise continually throughout pregnancy, suppressing the hypothalamic axis and subsequently the menstrual cycle. [Estrogen](#) is mainly produced by the [placenta](#) and is associated with fetal well-being. Women also experience increased [human chorionic gonadotropin](#) ( $\beta$ -hCG); which is produced by the placenta. This maintains [progesterone](#) production by the [corpus luteum](#). The increased progesterone production, first by corpus luteum and later by the placenta, functions to relax bronchiolar smooth muscle. Elevated progesterone levels also contribute to an increase in [ventilation](#) to 50% greater than non-pregnant levels.

[Prolactin](#) levels increase due to maternal [pituitary gland](#) enlargement by 50%. This mediates a change in the structure of the [mammary gland](#) from ductal to lobular-alveolar. [Parathyroid hormone](#) is increased which leads to increases of calcium uptake in the gut and reabsorption by the kidney. Adrenal hormones such as [cortisol](#) and [aldosterone](#) also increase.

[Human placental lactogen](#) (hPL) is produced by the placenta and stimulates lipolysis and fatty acid metabolism by the woman, conserving blood glucose for use by the fetus. It can also decrease maternal tissue sensitivity to insulin, resulting [gestational diabetes](#).<sup>[1]</sup>

## Body Weight

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One of the most noticeable alterations in pregnancy is the gain in weight. The enlarging uterus, the growing fetus, the [placenta](#) and [liquor amnii](#), the acquisition of fat and water retention, all contribute to this increase in weight. The weight gain varies from person to person and can be anywhere from (2.3 kg) to over (45 kg). In America, the doctor-recommended weight gain range is (11 kg) to (16 kg),

## Cardiovascular

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During the course of pregnancy, blood volume slowly increases by 40–50%.<sup>[1]</sup> The increase is mainly due to an increase in plasma volume through increased [aldosterone](#). It results in an increase in [heart rate](#) (15 beats/min more than usual), [stroke volume](#), and [cardiac output](#). Cardiac output increases by about 50%, mostly during the first trimester. The systemic vascular resistance also slightly decreases due to smooth muscle relaxation and overall [vasodilation](#) caused by elevated progesterone. Diastolic [blood pressure](#) consequently decreases between 12–26 weeks, and increases again to pre-pregnancy levels by 36 weeks. If the blood pressure becomes abnormally high, the woman should be investigated for [pre-eclampsia](#) and other causes of [hypertension](#).

Cardiac function is also modified, with increased heart rate and increased stroke volume (is the volume of [blood](#) pumped from the left [ventricle](#) per beat).. A decrease in vagal tone and increase in sympathetic tone is the cause. After pregnancy the change in stroke volume is not immediately reversed. Cardiac output rises from 4 to 7 liters in the 2nd trimester.

## Haematology

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During pregnancy the [plasma](#) volume increases by 50% and the red blood cell volume increases only by 20–30%.

<sup>[1]</sup>Consequently, the [hematocrit](#) decreases on lab value; this is not a true decrease in hematocrit, however, but rather due to the dilution. The white blood cell count increases and may peak at over 20 mg/mL in stressful conditions. Conversely, there is a decrease in platelet concentration to a minimal normal values of 100-150 mil/mL.

A pregnant woman will also become [hypercoagulable](#), leading to increased risk for developing blood clots and embolisms, due to increased [liver](#) production of coagulation factors, mainly [fibrinogen](#) and [factor VIII](#) (this hypercoagulable state along with the decreased ambulation (exercise involving legs) causes an increased risk of both [DVT](#) and [PE](#)). Women are at highest risk for developing clots, or thrombi, during the weeks following labor. Clots usually develop in the left leg or the left iliac venous system. The left side is most afflicted because the left iliac vein is crossed by the right iliac artery. The increased flow in the right iliac artery after birth compresses the left iliac vein leading to an increased risk for thrombosis (clotting) which is exacerbated by the lack of ambulation following delivery. Both underlying [thrombophilia](#) and [cesarean section](#) can further increase these risks.

[Edema](#), or swelling, of the feet is common during pregnancy, partly because the enlarging uterus compresses veins and lymphatic drainage from the legs.

## Metabolic

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During pregnancy, both [protein metabolism](#) and [carbohydrate metabolism](#) are affected. One [kilogram](#) of extra [protein](#) is deposited, with half going to the [fetus](#) and [placenta](#), and another half going to [uterine](#) contractile proteins, [breast glandular](#) tissue, plasma protein, and [haemoglobin](#).

An increased requirement for nutrients is given by fetal growth and fat deposition. Changes are caused by steroid hormones, lactogen, and cortisol.

Maternal insulin resistance can lead to [gestational diabetes](#). Increased liver metabolism is also seen, with increased gluconeogenesis to increase maternal glucose levels.<sup>[\[citation needed\]](#)</sup>

## Nutrition

Nutritionally, pregnant women require a caloric increase of 300 kcal/day and an increase in protein to 70 or 75 g/day.<sup>[\[citation needed\]](#)</sup> There is also an increased [folate](#) requirement from 0.4 to 0.8 mg/day (important in preventing [neural tube defects](#)). On average, a weight gain of 20 to 30 lb (9.1 to 13.6 kg) is experienced.<sup>[\[citation needed\]](#)</sup>

All patients are advised to take [prenatal vitamins](#) to compensate for the increased nutritional requirements. The use of Omega 3 fatty acids supports mental and visual development of infants.<sup>[\[14\]](#)</sup> Choline supplementation of research mammals supports mental development that lasts throughout life.<sup>[\[15\]](#)</sup>

## Renal tract

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A pregnant woman increases in kidney and ureter size. The [glomerular filtration rate](#) (GFR) commonly increases by 50%, returning to normal around 20 weeks [postpartum](#).<sup>[\[13\]](#)</sup> Plasma [sodium](#) does not change because this is offset by the increase in GFR. There is decreased [blood urea nitrogen](#) (BUN) and [creatinine](#) and glucosuria (due to saturated tubular reabsorption) may be seen. Persistent glucosuria may suggest [gestational diabetes](#). The [renin-angiotensin system](#) is upregulated, causing increased [aldosterone](#) levels.

## Gastrointestinal

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During pregnancy, woman can experience nausea and vomiting ([morning sickness](#)); which may be due to elevated [B-hCG](#) and should resolve by 14 to 16 weeks.<sup>[\[citation needed\]](#)</sup> Additionally, there is prolonged gastric empty time, decreased gastroesophageal sphincter tone, which can lead to [acid reflux](#), and decreased colonic motility, which leads to increased water absorption and [constipation](#).

## Immune tolerance

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The [fetus](#) inside a pregnant woman may be viewed as an unusually successful [allograft](#), since it genetically differs from the woman.<sup>[\[12\]](#)</sup> In the same way, many cases of [spontaneous abortion](#) may be described in the same way as maternal [transplant rejection](#).<sup>[\[12\]](#)</sup>

## Musculoskeletal

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Neuromechanical adaptations to pregnancy refers to the change in gait, postural parameters, as well as [sensory feedback](#), due to the numerous anatomical, physiological, and hormonal changes women experience during [pregnancy](#). Such changes increase their risk for [musculoskeletal](#) disorders and fall injuries. Musculoskeletal disorders include lower-back pain, leg

cramps, and [hip pain](#). Pregnant women fall at a similar rate (27%) to women over age of 70 years (28%). Most of the falls (64%) occur during the second trimester. Additionally, two-thirds of falls are associated with walking on slippery floors, rushing, or carrying an object.<sup>[18]</sup> The root causes for these falls are not well known. However, some factors that may contribute to these injuries include deviations from normal [posture](#), [balance](#), and [gait](#).

The body's posture changes as the pregnancy progresses. The pelvis tilts and the back arches to help keep balance. Poor posture occurs naturally from the stretching of the woman's abdominal muscles as the fetus grows. These muscles are less able to contract and keep the lower back in proper alignment. The pregnant woman has a different pattern of gait. The step lengthens as the pregnancy progresses, due to weight gain and changes in posture. On average, a woman's foot can grow by a half size or more during pregnancy. In addition, the increased body weight of pregnancy, fluid retention, and weight gain lowers the arches of the foot, further adding to the foot's length and width. The influences of increased hormones such as [estrogen](#) and [relaxin](#) initiate the remodeling of soft tissues, cartilage and ligaments. Certain skeletal joints such as



the [pubic symphysis](#) and [sacroiliac](#) widen or have increased laxity.<sup>[citation needed]</sup>

The addition of mass, particularly around the [torso](#), naturally changes a pregnant mother's [center of mass](#) (COM). The change in COM requires pregnant mothers to adjust their bodies to maintain [balance](#).

Pelvis and back body posture during pregnancy

# PHYSIOLOGICAL CHANGES OF PREGNANCY

- Reproductive system
  - Size of uterus
  - Braxton Hicks contractions
  - Hegar's Sign
- Cardiovascular system
  - Blood flow increases to uterus
  - Heart rate increases by 10-15 BPM
  - Cardiac Output increases by 30-50%
  - B/P decreases, lowest during 2<sup>nd</sup> trimester, returns 3<sup>rd</sup> trimester
  - Lower extremity edema, varicose veins of legs, vulva, or rectum
  - Supine hypotensive syndrome-dizziness, clammy-pale skin, low b/p, decreased placental perfusion
  - Blood volume increases by 30-50% and peaks at week 30
  - Small increase in RBC, greater increase in PLASMA (shows lower hematocrit 34-40% known as **physiologic anemia of pregnancy**)
  - WBC increases by week 8
  - Plt, fibrin, fibrinogen, and coagulation VII, IX, X increases  
(increases the risk of venous thrombosis late in pregnancy)

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## Physiological Changes During Pregnancy

- Skin
  - Changes thought to occur due to increased estrogen, progesterone and alpha-melanocyte-stimulating hormone levels
  - Sweat and sebaceous glands usually hyperactive
  - Angiomas (telangiectasias) - Vascular spider nevi may appear on the chest, neck, face, arms and legs. Of no clinical significance and disappear after pregnancy. Due to increased levels of estrogen
  - Palmar erythema - color changes which occur over the palmar surface of the hands. Due to increased levels of estrogen and progesterone

## CHANGES OF THE CIRCULATORY SYSTEM DURING PREGNANCY

### ■ Blood Volume.

- (1) Blood volume increases gradually by 30 to 50 percent. This results in decrease concentration of red blood cells and hemoglobin. This explains why the need for iron is so important during pregnancy.
- (2) Increased blood volume compensates for hypertrophied vascular system of enlarged uterus. It improves the placental performance. Blood lost during delivery, less than 500 cc is normal



# Physiological Changes During Pregnancy

## ■ Respiratory System

- Maternal oxygen requirements increase
  - Increase in BMR
  - Need to add tissue mass in uterus and breast
  - Fetus requires oxygen and needs to dispose of carbon monoxide
- Elevated estrogen levels
  - cause ligaments of rib cage to relax which allows increased chest expansion
  - Cause an increase in vascularization in upper respiratory tract
    - → capillary congestion → nasal & sinus congestion, nosebleeds, changes in voice, changes in respiratory center (a lower threshold for CO<sub>2</sub>)
- During advanced pregnancy, increased awareness of the need to breathe evident; some complain of SOB; some complain of dyspnea at rest

## 5-Changes in the Gastrointestinal System

- Gastrointestinal motility, food absorption, and lower esophageal sphincter pressure are **decreased** during pregnancy, probably due to an increased level of plasma progesterone
- Gastric emptying time is significantly **slower** during labor and hence gastric volume is increased
- Gallbladder function and emptying are **impaired** during pregnancy, and there is possibility of gallstone problems.



## RENAL CHANGES

- Renal vasodilatation increases renal blood flow early during pregnancy.
- Increased Cardiac output leads to Increased GFR & Increased renal plasma flow by 50% which increases clearance of urea, uric acid and Creatinine.
- Increased Renin & Aldosterone level promotes Na<sup>+</sup> retention leading to volume overload.
- Decreased Renal tubular threshold for glucose & amino acids → mild glycosuria & proteinuria (< 300mg/d).
- Progesterone mediated ueretic smooth muscle relaxation can lead to urinary stasis making pregnant women prone to urinary tract infections.

There is increase in the volume of distribution for drugs and may have to be given in higher than normal dosages.

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