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**COLLEGE: MEDICINE AND HEALTH SCIENCES**

**COURSE: PHYSIOLOGY**

**Elucidate the physiological adaptations of the female to pregnancy**

**Changes in estrogen and progesterone:**

 A woman will produce more estrogen during one pregnancy than throughout her entire life when not pregnant. During pregnancy, estrogen promotes maternal blood flow within the uterus and the placenta. A pregnant woman’s progesterone levels are also very high. Among other effects, high levels of progesterone cause some internal structures to increase in size, including the uterus, enabling it to accommodate a full-term baby. It has other effects on the blood vessels and joints.

**Changes in the uterus, cervix and vagina**

The uterus: After conception, the uterus provides a nutritive and protective environment in which the fetus will grow and develop. It increases from the size of a small pear in its non-pregnant state to accommodate a full-term baby at 40 weeks of gestation. The tissues from which the uterus is made continue to grow for the first 20 weeks, and it increases in weight from about 50 to 1,000 gm (grams). After this time, it doesn’t get any heavier, but it stretches to accommodate the growing baby, placenta and amniotic fluid. By the time the pregnancy has reached full term, the uterus will have increased to about five times its normal size:

* In height (top to bottom) from 7.5 to 30 cm
* In width (side to side) from 5 to 23 cm
* In depth (front to back) from 2.5 to 20 cm.

At 12 weeks’ gestation (near the end of the first *trimester*, i.e. three-month period), the **fundus** (upper margin of the body of the uterus) may be palpated (felt) through the abdomen above the pubic bone (symphysis pubis). The size of the uterus usually reaches its peak at about 36 weeks’ gestation.



The uterus may drop slightly as the fetal head settles into the pelvis, preparing for delivery. Notice the position at 40 weeks of gestation, which is shown as a dotted line in Figure 7.1. This dropping is referred to as ‘lightening’. It is more noticeable in a **primigravida** (pregnant for the first time) than in a **multigravida** (a woman who has been pregnant previously, regardless of outcome).

**The cervix**

The cervix remains 2.5 cm long throughout pregnancy. In late pregnancy, softening of the cervix occurs in response to increasing painless contractions of its muscular walls.

**The vagina**

The vagina also becomes more elastic towards the end of pregnancy. These changes enable it to dilate during the second stage of labor, as the baby passes down the birth canal.

**Pregnancy-related changes in posture and joints**

A pregnant woman’s entire posture changes as the baby gets bigger. Her abdomen transforms from flat or concave (dished) to very convex (bulging outwards), increasing the curvature of her back. The weight of the fetus, the enlarged uterus, the placenta and the **amniotic fluid** (the bag of waters surrounding the baby), together with the increasing curvature of her back, puts a large strain on the woman’s bones and muscles. As a result, many pregnant women get back pain. Too much standing in one place or leaning forward can cause back pain, and so can hard physical work. Most kinds of back pain are normal in pregnancy, but it can also be a warning sign of a kidney infection. In addition, progesterone causes a loosening of ligaments and joints throughout the body. Pregnant women may be at greater risk of sprains and strains because the ligaments are looser, and because their posture has changed.

###  **Changes in body weight during pregnancy**



Continuing weight increase in pregnancy is considered to be one favorable indication of maternal adaptation and fetal growth. However, routine weighing of the mother during pregnancy is not now thought to be necessary, because it does not correlate well with pregnancy outcomes. For example, there can be a slight loss of weight during early pregnancy if the woman experiences much nausea and vomiting (often called ‘**morning sickness**’). The expected increase in weight of a healthy woman in an average pregnancy, where there is a single baby, is as follows:

* About 2.0 kg in total in the first 20 weeks
* Then approximately 0.5 kg per week until full term at 40 weeks
* A total of 9 -12 kg during the pregnancy.

A woman who is pregnant with more than one baby will have a higher weight gain than a woman with only one fetus. She will also require a higher calorie diet.

A lack of significant weight gain may not be a cause for concern in some women, but it could be an indication that the fetus is not growing properly. Doctors and midwives may refer to this as intrauterine growth restriction (IUGR) of the fetus.

### **Changes in the cardiovascular system**

The **cardiovascular system** consists of the heart, the blood vessels (veins and arteries), and the blood that circulates around the body. It is the transport system that supplies oxygen and nutritive substances absorbed from the gastrointestinal tract to all the cells, tissues and organs of the body, enabling them to generate the energy they need to perform their functions. It also returns carbon dioxide, the waste product of respiration, to the lungs, where it is breathed out. The chemical processes that go on in the body generate many waste products, which the blood transports to the kidneys and liver, where they are removed. Other functions of the cardiovascular system include the regulation of body temperature, and the circulation and delivery of hormones and other agents that regulate body functions. There are several significant changes in this complex system during pregnancy.

#### The heart

The heart may increase in size during pregnancy due to an increase in its workload.

* Why do you think the workload of the heart has to increase?

 Because it has to pump blood through the placenta, fetus and the much larger uterus and abdomen of the pregnant woman.

The amount of blood that is pumped out of the heart each minute is called the **cardiac output**. Table 7.1 shows how it increases during pregnancy.

##### Changes in cardiac output during pregnancy

|  |  |
| --- | --- |
| **Woman’s condition** | **Cardiac output (liters per minute)** |
| non-pregnant, resting | 2.5 |
| end of 1st trimester | 5 |
| end of 2nd trimester | 6 |
| full-term | 7 |

The increase in cardiac output is caused by two changes in how the heart functions:

* Increase in the resting **heart rate**, i.e. the number of heart beats per minute. The heart rate is about 15 beats per minute higher in the pregnant woman.
* Increase in the **stroke volume**, i.e. the volume of blood pumped out of the heart in a single heartbeat. It is about 7 milliliters (ml) larger per heart beat in the pregnant woman.

Cardiac output is calculated by multiplying heart rate and stroke volume.

During the second trimester of pregnancy, the mother’s heart at rest is working 40% harder than in her non-pregnant state. Most of this increase results from a more efficiently performing heart, which ejects more blood at each beat.

#### Blood volume

**Blood volume** (the total volume of blood in the circulation, measured in liters) increases gradually by 30-50 % in the pregnant woman, so by full term she has about 1.5 liters more blood than before the pregnancy. A higher circulating blood volume is required to provide extra blood flow through the placenta, so nutrients and oxygen can be delivered to the fetus. The increase in blood volume is caused by two changes:

* Increase in the volume of blood plasma (the fluid part of the blood).
* Increase in the number of red blood cells in the circulation.

The volume of blood plasma increases after about the sixth week of pregnancy. It reaches its maximum level of approximately 50% above non-pregnant values by the second trimester, and maintains this until full term.

The total volume of red cells in the circulation increases by about 18% during pregnancy, in response to the extra oxygen requirements made by the maternal, placental and fetal tissues. Red blood cells contain the oxygen-carrying substance called hemoglobin, which is rich in iron. Taking iron supplements during pregnancy can result in a much greater increase in red blood cells, up to 30% more than non-pregnant levels.

##### Iron, hemoglobin and anemia

**Iron** is present in all cells and has several important functions, including oxygen transport and storage in the human body. It is the critical component of the oxygen-carrying substance **hemoglobin**, found in all red blood cells. It is the iron in hemoglobin that makes these cells appear red. If the diet is too low in iron, the person cannot make enough red blood cells. Iron is also involved in the storage and release of oxygen in the muscles.

**Anemia** is most accurately defined as a low concentration of hemoglobin in the blood, but it is often referred to as a low concentration of red blood cells. Too little iron in the diet is the leading cause of anemia.

Although there is a constant increase in the number of red blood cells in the circulation during pregnancy, the increase in the volume of blood plasma is much larger. So even though the pregnant woman has more red blood cells than before she was pregnant, they are *diluted* in the much larger volume of blood plasma.

* What effect will this have on the concentration of red blood cells and hemoglobin in the pregnant woman’s blood, compared to her non-pregnant self?

The concentration of red blood cells and hemoglobin will fall because they are more dilute, so the woman’s blood will be slightly anemic.

This effect is referred to as **physiological anemia**. It explains why iron in the diet, or from iron tablets, is so important during pregnancy.

#### Blood pressure in pregnancy

We said earlier that progesterone causes the ligaments and joints to loosen during pregnancy. It also acts with some other natural chemicals in the body to cause the muscular walls of the blood vessels to relax slightly. The result is that there is less resistance to the flow of blood around the body, because the same volume of blood is circulating in slightly wider blood vessels. **Blood pressure** (**BP**) refers to how hard the blood is ‘pushing’ on the walls of the major blood vessels as it is pumped around the body by the heart.

* What effect will the slight relaxation of the blood vessel walls have on the pregnant woman’s blood pressure?

It will be *lower* than in her pre-pregnant state, because the same volume of blood has more space in which to circulate.

Lower blood pressure is particularly common in early pregnancy. Many women report occasionally feeling dizzy in the first trimester, because less blood and less oxygen is being pumped to the brain. Progesterone can also cause a sudden larger relaxation in the blood vessels, resulting in an acute feeling of dizziness, or even a brief loss of consciousness (passing out).

Another cause of dizziness can result from lying flat on the back. This is more common after 24 weeks of pregnancy, but it can happen earlier during twin pregnancies, or conditions that increase the volume of amniotic fluid (waters surrounding the fetus). When a pregnant woman is lying flat on her back, the weight of her uterus and its contents compresses the large blood vessel (vena cava) leading from her lower body to the heart. When this blood vessel is squashed, the blood flow back to the heart is reduced, which in turn leads to a reduction in the blood flow out of the heart to the rest of the body.

* If there is suddenly less blood leaving the heart, what will happen to the woman’s blood pressure, and how will she feel as a result?

Lying flat on her back can result in a sudden and dramatic drop in blood pressure, and dizziness or loss of consciousness may occur because not enough oxygen is reaching her brain. After the first trimester, pregnant women are recommended not to lie on their back.

#### Exercise and blood flow in pregnancy

The weight gain in pregnant women increases the workload on the body from any physical activity. Steady, non-violent exercise is good for the mother because it prepares her body for labor, but sudden strong exercise, or working for too many hours without a break, may make her feel dizzy. This is because the reduced blood pressure and slight physiological anemia cannot keep pace with the demand of her body for more oxygen.

Having too much or too little exercise should be avoided in pregnancy.

A pregnant woman should not do exercises where she is lying on her back, due to the compression of the major blood vessels returning blood to her heart. Strong exercise may lead to decreased blood flow to the uterus because blood is diverted to the muscles, but this has not been shown to have any long-term effects on the baby. Pregnant women should not exercise vigorously in hot weather, or if it makes them breathless, or if there are known risk factors such as a history of miscarriage.

**Oedema in pregnancy**

If a pregnant woman experiences severe oedema, including swelling of the face, this is a danger sign that requires immediate referral to the nearest health facility.

A combination of the slight increase in the permeability of the smallest of blood vessels (they allow more fluid to leak out into the tissues), the additional weight of the uterus, and the downward force of gravity, slow down the rate at which blood is pumped back to the heart from the lower half of the body. Fluid often collects in the tissues of the legs and feet of pregnant women after the first trimester, instead of being absorbed into the blood circulation. The swelling caused by this collection of fluid is called **oedema**.

It is a common condition in pregnant women, particularly if they stand for a long time during the day. Oedema of the hands may also occur. Advise the woman to rest frequently and to elevate (raise) her feet and legs while sitting. This will improve the return of blood to her heart and decrease swelling of the legs.

### **Respiratory changes**

During pregnancy, the amount of air moved in and out of the lungs increases by nearly 50% due to two factors:

* each breath contains a larger volume of air
* the rate of breathing (breaths per minute) increases slightly.

During pregnancy, many women find they get short of breath (cannot breathe as deeply as usual). This is because the growing baby crowds the mother’s lungs and she has less room to breathe. But if a woman is also weak and tired, or if she is short of breath all of the time, she should be checked for signs of sickness, heart problems, anemia or poor diet. Get medical advice if you think she may have any of these problems.

### **Changes in the gastrointestinal system in pregnancy**

As you may remember from your high school biology, food and fluids enter the **gastrointestinal system** in the mouth, pass through the oesophagus, stomach and intestines, and solid waste exits at the anus. This very long tube from mouth to anus is often called the ‘gut’. Proteins, fats and carbohydrates in our diet are broken down (digested) in the gut into units small enough to be absorbed from the intestines into nearby blood vessels. It is also the route by which nutritious substances, such as vitamins and minerals, enter the body.

During pregnancy, the muscles in the walls of the gastrointestinal system relax slightly, and the rate at which food is squeezed out of the stomach and along the intestines is slowed down.

* Can you think of a reason why slowing down the passage of food through the gastrointestinal system might be beneficial in pregnancy?

It increases the time available for digestion, and it maximizes the absorption of nutrients from the diet.

Undesirable effects also result from slow emptying of the stomach, and slow movement of food through the gut.

* Can you suggest one of these undesirable effects?

Many pregnant women experience constipation (difficulty in passing stools).



The growing baby crowds the mother’s stomach and can cause indigestion and heartburn. She may also feel short of breath because the baby crowds her lungs.

Many women also have nausea in the first months of pregnancy. A burning feeling, or pain in the stomach or between the breasts, is called indigestion (or ‘heartburn’, although the heart is not involved). It happens because as the pregnancy progresses, the growing baby crowds the mother’s stomach and pushes it higher than usual (Figure 7.3). The acids in the mother’s stomach that help digest food are pushed up into her chest, where they cause a burning feeling. This is not dangerous and usually goes away after the birth.

If the mother has difficulty with nausea or indigestion, advise her to eat small, frequent meals. The mother should not lie down flat for 1 to 2 hours after eating, because this may cause these symptoms. In Study Session 12 you will learn more about minor disorders of pregnancy such as these, and how to help the woman manage them.

### **Changes in the urinary system during pregnancy**

The **urinary system** consists of the kidneys (a pair of organs on either side of the abdomen near the back), the tubes connecting the kidneys to the bladder where urine is stored, and a tube called the **urethra** that passes urine out of the body. (Look back at Figure 3.1 in Study Session 3, to remind yourself of the position of the bladder and the urethra.) The kidneys extract waste from the blood and turn it into urine. They must work extra hard to filter the mother’s own waste products from her blood, plus those of the fetus, and get rid of them in her urine. Therefore, there is also an increase in the amount of urine produced during pregnancy.



Needing to urinate (pee) often is normal, especially in the first and last months of pregnancy. This happens because the growing uterus presses against the bladder. In late pregnancy, a woman often has to get up during the night to urinate, because fluid retained in the legs and feet during the day (oedema) is absorbed into the blood circulation when her legs are raised in bed. The kidneys extract the excess fluid and turn it into urine, so the bladder fills more quickly at night.

###  **Skin changes**

Changes in the woman’s hormones, and mechanical stretching of her growing abdomen and breasts, are responsible for several changes in the skin during pregnancy.

####  Linea nigra

This dark line may appear between the umbilicus (belly-button) and the symphysis pubis (pubic bone); in some pregnant women it may extend as high as the sternum (the bone between the breasts). It is a hormone-induced excess production of brown material (pigment) in the skin cells in this area. After delivery, the line begins to fade, though it may never completely disappear.

#### Mask of pregnancy (chloasma)

Some women produce a brownish pigmentation of the skin over the face and forehead, known as the ‘mask of pregnancy’ (or chloasma). It gives a bronze look. It begins about the 16th week of pregnancy and gradually increases, but it usually fades after delivery. You will learn more about it in Study Session 8.

#### Stretch marks

As the woman’s weight increases, stretching of the skin occurs over areas of maximal growth — the abdomen, thighs and breasts. Pink or brownish stretch marks may appear in some women, which can be quite dramatic. They usually fade after delivery, although they never completely disappear.

#### Sweat glands

Activity of the sweat glands throughout the body usually increases during pregnancy, which causes the woman to perspire (sweat) more profusely than usual, particularly in hot weather or during physical work.

### **Changes in the breasts**

In early pregnancy, the breasts may feel full or tingle, and they increase in size as pregnancy progresses. The **areola** around the nipples (the circle of pigmented skin) darkens and the diameter increases. The Montgomery’s glands (the tiny bumps in the areola) enlarge and tend to protrude (stick out more). The surface blood vessels of the breast may become visible due to increased circulation, and this may give a bluish tint to the breasts.



By the 16th week (during the second trimester), the breasts begin to produce **colostrum**. This is the precursor of breastmilk. It is a yellowish secretion from the nipples, which thickens as pregnancy progresses. It is extremely high in protein and contains **antibodies** (special proteins produced by the mother’s immune system) that help to protect the newborn baby from infection. Near the end of pregnancy, the nipples may produce enough colostrum to make wet patches on the woman’s clothes. Reassure her that this is normal and a good sign. After the baby is born, colostrum is produced for about the first three days, before the proper milk begins to flow. Make sure that the mother breastfeeds the colostrum to her baby, so he or she gets all the nutrients and antibodies it contains.