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Effect of Gestation on Some Physiological and Blood Parameters in Adult Healthy Women

Research project

Submitted to the department of Biology in partial fulfillment of the requirements for the degree of BSc. In Biology

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Supervisor's Certification

I certify that this project was prepared under my supervision at the Department of Biology, College of Science, Salahaddin University-Erbil, and I do hereby recommend it to be accepted as partial fulfillment of the requirements for the BSc. in **Biology/Animal Physiology.**

Signature:

Supervisor

Assist. Prof. Dr. Edrees M. Ameen

Date: 2 / 4 / 2023

Dedicated to

To my family and friends

Sara and Ala

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Abstract

The present study was done and aimed to evaluate the effect of gestation on some physiological and blood parameters in adult healthy women. The study included 150 pregnant women and 50 non-pregnant women used as the control group. The samples were taken from Mala Fandy Family Medicine Center and Rajan Center for Consultation and Polyclinic in Erbil City. The results showed a significant increase in the body mass index in pregnant women when compared with the control group. Also, the third gestational trimester has a significantly higher body mass index when compared with the first and second trimesters. Regarding blood pressure and heart rate, fasting blood sugar, and HbA1c pregnant women showed significantly higher values of systolic blood pressure, heart rate, fasting blood sugar, and HbA1c as compared with the control group and the third gestational trimester observed significantly higher systolic blood pressure, blood sugar, and HbA1C than the first and second trimesters, while heart rate significantly increased in the second and third gestational trimester. Red blood cells (RBC), hemoglobin (Hb), and hematocrit, were significantly decreased with the progression of the gestation, and the lower concentration was recorded in the third trimester. Total white blood cells (WBC) were increased with the progression of gestation and a higher concentration was recorded in the third trimester.

Keywords: Gestation; Blood pressure; HbA1c; RBC; Hb, WBC, blood sugar; BMI.

1. Introduction

Pregnancy is the physiological state. Human pregnancy is the most studied of all mammalian pregnancies. Childbirth usually takes about 38 weeks after conception, which is approximately 40 weeks from the last menstrual period. The WHO defined the normal term for delivery as between 37 weeks and 42 weeks. A woman's reproductive period is roughly from 15 to 45 years –30 years. Pregnancy causes

physiological and anatomical changes in different body systems (Biswas and Kulsange, 2013, Teli and Bagali, 2013). The physiological changes occurring in a pregnant woman are vast and widespread. These include changes in genital organs, an increase in breast size, weight gain, and other systemic alterations including respiratory, cardiovascular, body water metabolism, hematological, and metabolic changes (Omorogiuwa and Iyawe, 2015). These adaptations are necessary to meet the increased metabolic demands of the mother and the fetus

Pregnancy can be complicated by many involved factors like hemorrhage, infection, preterm labor, cervical insufficiency, hypertension, and gestational diabetes. Hypertension complications are involved in roughly 5-10% of pregnancy cases after mid gestation1 and 10-15% of all maternal deaths are associated with it (Kumari et al., 2014). Hypertensive disorders of pregnancy (HDP) remain one of the major causes of pregnancy-related maternal and fetal morbidity and mortality worldwide. Affected women are also at increased risk for cardiovascular disease later in life, independently of traditional cardiovascular disease risks (Garovic et al., 2022). Most guidelines around the world are aligned in defining hypertension in pregnancy as blood pressure (BP) ≥140/90 mm Hg (Obstetricians and Gynecologists, 2019).

GDM is one of the most common medical complications of pregnancy, and its inadequate treatment can lead to serious adverse health effects for the mother and child (Crowther et al., 2005, Buchanan et al., 2012). According to the latest estimates of the International Diabetes Federation (IDF), GDM affects approximately 14.0% of pregnancies worldwide, representing approximately 20 million births annually (Wang et al., 2022). Mothers with GDM are at risk of developing gestational hypertension, pre-eclampsia, and termination of pregnancy via Caesarean section (Kondracki et al., 2022). In addition, GDM increases the risk of complications, including cardiovascular disease, obesity, and impaired carbohydrate metabolism, leading to the development of type 2 diabetes (T2DM) in both mother and infant (Lenoir-Wijnkoop et al., 2015, Lee et al., 2018, McIntyre et al., 2019).

Anemia is one of the most frequent complications related to pregnancy. Several studies have been published regarding anemia during pregnancy, and it is known to be associated with an increased risk of adverse pregnancy outcomes, such as premature delivery, low birth weight, and small-for-gestational-age (SGA) neonates (Sukrat et al., 2013, Ronkainen et al., 2019). However, the prevalence of anemia is very different by maternal ethnicity and socioeconomic status. Therefore, research investigating the relationship between anemia and pregnancy outcomes across diverse ethnic groups is still needed.

The present study was done and aimed to evaluate the effect of gestation on BMI, some physiological related to the cardiovascular system, blood sugar, and some blood parameters in adult healthy women.

2. Materials and methods

2.1. Subject

The present study includes 200 women aged between 20 and 35 years with no significant differences between the groups from Mala Fandy Family Medicine Center and Rajan Center for Consultation and Polyclinic in Erbil City. The women were divided into four groups, as follows:

Group 1: (50 healthy none pregnant women used as a control group).

Their mean ages of them were 25.12 ± 1.65.

Group 2: (50 healthy pregnant women during the 1st trimester).

The mean ages were 26.04 ± 1.01

Group 3: (50 healthy pregnant women during the 2nd trimester).

The mean ages were 25.50 ± 0.90.

Group 4: (50 healthy pregnant women during the 3rd trimester).

The mean ages were 24.84 ± 0.83.

The study has been conducted during the period from October 2022 to March 2023.

2.2. BMI

The body mass index (BMI), or Quetelet index, is a measure of relative weight based on an individual's mass and height. Devised between 1830 and 1850 by the Belgian polymath Adolphe Quetelet during the developing "social physics", it is defined as the individual's body mass divided by the square of their height – with the value universally being given in units of kg/m^2 (Eknoyan, 2008).

$$\mathrm{BMI} = \frac{\mathrm{mass(kg)}}{(\mathrm{height(m)})^2}$$

For these individuals, the current value settings are as follows: a BMI of 18.5 to 25 may indicate the optimal weight, a BMI lower than 18.5 suggests the person is underweight, a number above 25 may indicate the person is overweight, a number above 30 suggests the person is obese.

2.3. Collection of blood samples

For each subject, 5 ml of blood was obtained by vein puncture. The blood sample was used to measure blood glucose, HbA1c, RBC, Hb, Hematocrit, Total WBC, thrombocytes, and RDW.

2.4. Blood pressure and heart rate

Blood pressure (BP) is the pressure exerted by circulating blood upon the walls of blood vessels and is one of the principal vital signs. A person’s blood pressure is usually expressed in terms of the systolic (maximum) pressure over diastolic (minimum) pressure and is measured in millimeters of mercury (mm Hg). Normal resting blood pressure for an adult is approximately 120/80 mm Hg. Heart rate, or heart pulse, is the speed of the heartbeat measured by the number of poundings of the heart per unit of time — typically beats per minute (bpm). The heart rate can vary according to the body's physical needs, including the need to absorb oxygen and excrete carbon dioxide. The standard resting adult human heart rate ranges from 60–100 bpm. In the present study blood pressure and heart rate were measured by using of Digital blood pressure monitor (FULL auto Fuzzy, United Kingdom).

2.5. Blood glucose and HbA1c

HbA1c reflects average plasma glucose over the previous 8 to 12 weeks (Kim *et al*., 2011). It can be performed at any time of the day and does not require any special preparation such as fasting. These properties have made it the preferred test to assess glycaemic control in people with diabetes. The blood glucose and HbA1c are determined by using Cobas c311 Hitachi/Roche, Germany device.

2.6. Hematological parameters

The RBC, Hb, hematocrit, Total WBC, thrombocytes, and RDW were measured by using a Coulter Counter instrument.

2.8. Statistical analysis

Analysis of the data was performed using SPSS (Version 17). Results are expressed as means ± standard error. An independent t-test was used for the comparison of the studied parameters between control and pregnant women. Analysis of variance (ANOVA) and Tukey's post-Hoc test were used for the comparison of the studied parameters between the 1^{st}, $2^{nd,}$ and 3^{rd} trimesters. A p-value equal to or less than 0.05 was considered to be statistically significant.

3. Results and discussion

Table 1 showed the comparison of ages, height, weight, and BMI between control and pregnant women. No significant differences were observed in ages and height between control and pregnant women, while pregnant women showed significantly increased weight and body mass index (control; weight 62.23 ± 4.45kg and BMI 19.20 ± 0.86 vs. pregnant women; weight 74.80 ± 3.67kg and BMI 23.49 ± 0.45). Table (2) showed the comparison of height, weight, and BMI between the three trimester periods of pregnant women. No differences appeared between the three trimesters in height of pregnant women, while the weight and BMI significantly increased in the third trimester period when compared with the first and second trimesters. Nowadays, obesity is considered an individual and public health issue,

given its contribution to the development of several chronic diseases. The prevalence of obesity in the general population is increasing dramatically (Pakniat et al., 2015). Due to the rising prevalence of obesity within the past few decades, the rate of obesity during pregnancy has also increased. According to a 20-year cohort study, the prevalence of obesity during pregnancy increased from 15% in 1980 to 35% in 2000 (Chu et al., 2009).

Maternal overweight and obesity are widely associated with adverse pregnancy outcomes, such as gestational hypertension, preeclampsia, gestational diabetes mellitus, repeated cesarean section, and stillbirths (Doherty et al., 2006, Raatikainen et al., 2006). Overweight, obesity, and underweight are defined differently in various reports. Earlier studies have extensively explored the relationship between maternal height, maternal weight, and pregnancy complications, while Body Mass Index (BMI) is widely accepted as a better measurement of maternal overweight or underweight in more reports (Torloni et al., 2009, Athukorala et al., 2010). Weight gain during pregnancy includes three components: the product of conception (fetus, placenta, extracellular and amniotic fluid), maternal tissue expansion (uterus, breasts, and blood volume), and maternal fat reserve. Normal mean total gestational weight gain is estimated at 12.5kg (WHO, 1995).

Table 1. Comparison of ages, height, weight, and BMI between control and pregnant women (means ± standard errors).

	Control	**Pregnant women's**	**P-value**
Ages (years)	25.12 ± 1.65	25.46 ± 0.36	0.078
Height (cm)	160.20 ± 0.57	159.15 ± 0.47	0.093
Weight (kg)	62.23 ± 4.45	74.80 ± 3.67	0.001
BMI	19.20 ± 0.86	23.49 ± 0.45	0.023

Table 2. Comparison of height, weight, and BMI between trimesters of pregnant women (means ± standard errors).

	Height (cm)	Weight (kg)	BMI
1st trimester	160.40 ± 1.24 [a]	65.34 ± 4.02 [a]	19.92 ± 0.67 [a]
2nd trimester	159.82 ± 1.46 [a]	69.00 ± 3.45 [a]	21.58 ± 0.43 [a]
3rd trimester	160.34 ± 0.87 [a]	77.34 ± 2.67 [b]	23.67 ± 0.36 [b]

Table 3 showed the comparison of systolic blood pressure, diastolic blood pressure, and heart rate between control and pregnant women. Pregnant women showed significantly higher systolic blood pressure and heart rate when compared with control women. Table 4 showed the comparison of systolic blood pressure, diastolic blood pressure, and heart rate between the three trimester periods of pregnant women. The third trimester gestation period observed significantly higher systolic and diastolic blood pressure when compared with the first and second gestation periods. In addition, the second and third gestation trimester periods observed significantly higher heart rates when compared with the first period. These results are in agreement with the results recorded by (Kumari et al., 2014). The maternal cardiovascular system undergoes progressive adaptations throughout pregnancy, including decreased vascular resistance, increased blood volume, and other metabolic changes (Ouzounian and Elkayam, 2012). Although the effects of these changes on systemic blood pressure (BP) have been described in many studies, there is no consensus on its normal variation in (Tranquilli, 2011). In pregnant women clinically healthy, BP decreases until the middle of pregnancy, and then increases until the day of delivery, with final indices similar to the ones found at the beginning of pregnancy (Santos et al., 2005). The Resting Heart Rate (RHR) abruptly increases in the first trimester of pregnancy, followed by a moderate increase until the end (Wolfe and Davies, 2003).

Uncomplicated pregnancies Hypertensive disorders of pregnancy (HDP) represent a major obstetric complication that affects 5%-10% of pregnancies, depending on characteristics of the study population, and are one of the leading causes of maternal and neonatal morbidity and mortality worldwide. HDP includes chronic hypertension, gestational hypertension, preeclampsia, and eclampsia, which is considered the second most common cause of direct maternal death in developed countries (Rebelo et al., 2015).

The etiology of HDP is not clear; however, there are several risk factors associated with their occurrence, such as BMI (Ehrenthal et al., 2011). As the prevalence of obesity increases in women of reproductive age (Gaillard et al., 2011), BMI and its associated complications represent a relevant public health matter. Maternal obesity is a significant risk factor for morbidity and mortality for both mother and fetus. A systematic review has demonstrated that an increase of approximately 5-7 kg/m^2 units in BMI was associated with a two-fold increased risk of preeclampsia (O'Brien et al., 2003).

Hermida et al. (2001) also reported that blood pressure increases linearly during the second half of gestation in pregnancy-induced hypertension, the average blood pressure values for women who developed gestational hypertension and preeclampsia, are well within the normal ranges of blood pressure variability until the very late stages of pregnancy.

Table 3. Effect of pregnancy on blood pressure and heart rate (means ± standard errors).

	Control	**Pregnant women's**	**P-value**
Systolic blood pressure (mm Hg)	110.86 ± 0.76	120.36 ± 3.46	0.02
Diastolic blood pressure (mm Hg)	79.24 ± 1.204	83.45 ± 2.56	0.23
Heart rate (beat/minute)	78.36 ± 1.231	100.34 ± 5.67	0.001

Table 4. Comparison of blood pressure and heart rate between trimesters of pregnant women (means ± standard errors).

	Systolic blood pressure (mm Hg)	Diastolic blood pressure (mm Hg)	Heart rate (beat/minute)
1st trimester	116.900 ± 3.177 b	71.550 ± 1.631 b	95.600 ± 1.937 b
2nd trimester	111.850 ± 3.174 b	71.000 ± 2.313 b	99.500 ± 3.721 a
3rd trimester	136.083 ± 2.65 a	8.3.650 ± 1.646 a	99.517 ± 1.767 a

The results which are presented in Table 5 found that there is a significantly higher concentration of fasting blood sugar 100.25 ± 2.94 mg/dL and HbA1c 5.11 ± 0.26% in the pregnant women as compared with non-pregnant women 85.34 ± 3.87 mg/dL and HbA1c 4.59 ± 0.14 %. The 3rd trimester showed significantly higher concentrations of fasting blood sugar and HbA1c when compared with both 1st and 2nd trimesters, (Table 6). Gestational diabetes mellitus, which is defined as a state of hyperglycemia that is first recognized during pregnancy, is currently the most common medical complication in pregnancy. GDM affects approximately 15% of pregnancies worldwide, accounting for approximately 18 million births annually. Mothers with GDM are at risk of developing gestational hypertension, preeclampsia, and termination of pregnancy via Caesarean section. In addition, GDM increases the risk of complications, including cardiovascular disease, obesity, and impaired carbohydrate metabolism, leading to the development of type 2 diabetes in both the mother and infant (Modzelewski et al., 2022).

In the pathogenesis of GDM, as in type 2 diabetes, a key role is played by insulin resistance and decreased insulin secretion relative to the patient's needs. Insulin resistance in pregnancy is predisposed by the diabetogenic effect of placental hormones (human placental lactogen (hPL), human placental growth hormone (hPGH), growth hormone (GH), adrenocorticotropic hormone (ACTH), prolactin (PRL), estrogens and gestagens), increased secretion of pro-inflammatory cytokines

(tumor necrosis factor-alpha (TNF-), IL-6, resistin and C-reactive protein (CRP)), adiponectin deficiency, hyperleptinemia and central leptin resistance, impaired glucose transport in skeletal muscles, impaired insulin receptor signaling, and decreased expression and abnormal translocation of GLUT-4 to the cell membrane of adipocytes (Baeyens et al., 2016, Baz et al., 2016, Berberoglu, 2019). An increased secretion of insulin-antagonistic hormones (placental hormones, cortisol) during pregnancy results in an increased insulin resistance, which, at the end of the third trimester, reaches a value similar to full-blown type 2 diabetes (Plows et al., 2018).

Table 5. Effect of pregnancy on fasting blood sugar and HbA1c (means ± standard errors).

	Control	**Pregnant women's**	**P-value**
Fasting blood sugar (mg/dL)	85.34 ± 3.87	100.25 ± 2.94	0.01
HbA1c (%)	4.59 ± 0.14	5.11 ± 0.26	0.05

Table 6. Comparison of fasting blood sugar and HbA1c between trimesters of pregnant women (means ± standard errors).

	Fasting blood sugar (mg/dL)	**HbA1c (%)**
1st trimester	89.40 ± 2.44 ^{b}	4.73 ± 0.13 ^{b}
2nd trimester	87.25 ± 3.95 ^{b}	4.66 ± 0.24 ^{b}
3rd trimester	122.28 ± 4.62 ^{a}	5.91 ± 0.17 ^{a}

Pregnant women showed significantly lower concentrations of RBC, Hb, and hematocrit and higher leucocytes as compared with the control group, Table 7. The results found in Table 8 showed that the values of RBC, Hb, and hematocrit concentration were significantly decreased with the progression of the gestation, and the lower concentration was recorded in the third trimester. Also, RBC, Hb, and

hematocrit concentrations were significantly lower in women in 3rd trimester than that at 2nd. Leucocyte concentration was increased with the progression of gestation and the higher concentration was recorded in the third trimester. No differences appeared in leukocyte concentration between the 1st and 2nd trimesters. Moreover, platelets count decreased insignificantly with increasing the period of pregnancy.

Table 7. Effect of pregnancy on some blood parameters (means ± standard errors).

	Control	**Pregnant women's**	**P-value**
RBC ($\times 10^6$/µL)	4.25 ± 0.14	3.69 ± 0.24	0.05
Hb (g/dL)	13.24 ± 0.67	10.13 ± 0.89	0.05
Hematocrit (%)	38.45 ± 2.18	33.56 ± 2.87	0.05
Total leucocytes ($\times 10^3$/µL)	5.25 ± 0.36	8.35 ± 0.86	0.01
Platelets ($\times 10^3$/µL	236.16 ± 10.68	220.47 ± 11.54	0.08

Table 8. Comparison of some blood parameters between trimesters of pregnant women (means ± standard errors).

	1st trimeter	**2nd trimester**	**3rd trimester**
RBC ($\times 10^6$/µL)	3.98 ± 0.18 [a]	3.85 ± 0.17 [a]	3.39 ± 0.36 [b]
Hb (g/dL)	12.46 ± 0.68 [a]	11.34 ± 0.75 [a]	8.58 ± 0.89 [b]
Hematocrit (%)	37.66 ± 2.47 [a]	35.45 ± 2.36 [a]	32.87 ± 2.19 [b]
Total leucocytes ($\times 10^3$/µL)	6.10 ± 0.45 [a]	7.76 ± 0.65 [a]	9.35 ± 0.45 [b]
Platelets ($\times 10^3$/µL)	228.90 ± 9.56 [a]	222.32 ± 10.43 [a]	220.54 ± 9.78 [a]

The hematological parameter indicates the immunological, nutritional, and hemostatic condition of a pregnant woman and is considered a major factor affecting

the pregnancy (Shaw et al., 2010). The hematological profile of a pregnant woman has an impact on pregnancy and its outcome (Akingbola et al., 2006). The most common hematological indices are the indicators of hemoglobin concentration. Low hemoglobin in the blood is widely identified as a hematological abnormality and it is associated with adverse pregnancy outcomes (James et al., 2008). Physiologic anemia is the term often used to describe the fall in hemoglobin concentration that occurs during normal pregnancy resulting from plasma volume increasing above normal by the end of gestation although the red cell masses themselves increase by some and still lead to a fall in hemoglobin concentration with a feature of normocytic and normochromic type of anemia (Das et al., 2013). It is very difficult to define a normal reference range for hemoglobin concentration during pregnancy. According to the standard laid down by WHO, anemia in pregnancy is present when the hemoglobin concentration in the peripheral blood is 11 gm/dL or less. Anaemia contributes to intrauterine growth restriction, preterm labor, and abortions and it is also a primary cause of low immunity of both the mother and the baby, which makes them prone to several life-threatening infections (Osonuga et al., 2011).

The incidence of anemia in the third trimester of pregnancy is due to the status of iron deficiency in the body at the natural level (Rahman and Mohammed, 2018). In addition, the complication of anemia in the interval pregnancy includes a weakness in the transfer of oxygen which leads to hypoxia (Shu and Ogbodo, 2005). This could be explained that iron supplements can be reduced to the extent of iron depletion in the third trimester (Allen, 2000). Blood volume increased by approximately 40 to 45 % above pregnancy levels by the end of the third trimester. Blood plasma and red blood cells, both increase in volume, although plasma volume increases at a higher percentage (50%) (Ueland, 1976).

The results of the study showed that there were significant and high differences in white blood cells that are responsible for defending the body during pregnancy, and the number of lymphocytes was high and this is consistent with previous work (Luppi, 2003), who confirmed that the total lymphocyte count elevated in early pregnancy would remain elevated throughout pregnancy. This may be a result of the

body building up fetal immunity and this is achieved through a state of selective immune in which the pregnant woman was more exposed to different types of clinical disorders and infections with a variety of microbes due to a weak immune response especially cell-mediated immune response during pregnancy.

4. CONCLUSIONS

The current study concluded that the third gestational trimester has a higher body mass index, blood pressure, heart rate, fasting blood sugar, and HbA1c as compared with the control, 1st, and 2nd gestational trimesters. Regarding hematological parameters, women in the 3rd trimester showed lower RBC, Hb, and hematocrit, and higher Total WBC compared to the control, 2nd and 3rd trimesters.

Conflict of Interest

The authors declare no conflict of interest

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