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Review

Obesity in Pregnancy

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Abstract

Obesity is regarded as one of the major contemporary nutritional issues with features of a modern epidemic that affects not only the developed countries, but also the developing ones. Obesity can cause problems during pregnancy, concerning not only the maternal health and the outcome of pregnancy, but the subsequent health of the infant and the newborn as well. Obese pregnant women belong to the high-risk pregnancy group, as gestational diabetes mellitus, pre-eclampsia, and less frequently, infections and thromboembolic events can directly affect maternal health. The maternal and perinatal risks, associated with obesity in pregnancy, make it imperative today to treat this condition before and during pregnancy. The best and most effective treatment of obesity in pregnancy is prevention. Active weight loss interventions in obese pregnant women are prohibitive. Healthy diet and regular physical activity of pregnant women, are crucial steps towards the normal progression of the pregnancy. This article, based on the systematic citation of modern bibliographic data, attempts a brief review of the effects of the maternal obesity on the outcome of pregnancy and the role of nutrition and physical activity in the treatment of overweight and obese women, with the aim of ensuring the best in mother's health and the perinatal outcome.

Keywords: Maternal obesity, Pregnancy, Complications, Diet, Exercise

INTRODUCTION

Obesity is today one of the most serious public health issues in developed countries, with features of a modern epidemic, which in the future is estimated to replace the traditional public health concerns, such as malnutrition and infectious diseases (Barness et al., 2007; Loscalzo et al., 2008). Until the 20th century, obesity was considered a rare disorder (Haslam, 2007). Recent research data show that the rate of obesity worldwide is increasing. In both the US and China, the incidence of obesity has doubled over the last decade (Ding and Malik, 2008). In Europe the incidence of obesity depends on the geographical distribution of the population. It is estimated that rates are higher in Central, Eastern and Southern Europe than in Western and Northern Europe (Andreyeva et al., 2007; Berghöfer et al., 2008).

The most widely used measurement tool for the classification of obesity in the general population (Table 1) is Body Mass Index (BMI) (Polikandrioti, 2008). According to the World Health Organization an overweight person is characterized by a BMI of 25 to 29.9 kg/m^2, while obese is considered the one with a BMI of 30 kg/m^2 or more. The various modifications to the World Health Organization's definitions that have occasionally been attempted, concern mainly the type II and III obesity, which are being ranked in further subcategories. In particular, BMI of 35 to 39.9 is consistent with severe obesity, while BMI of 40 to 44.9 implies morbid obesity. Finally, BMI ≥ 45 is consistent with over-soreness (Sturm, 2007).

During pregnancy the weight gain of the woman should be progressive (Table 2), based on the pre-pregnancy nutritional status (Institute of Medicine, 1990). The guidelines currently available for the recommended weight gain during pregnancy are proportional to the woman's weight and BMI prior to conception. In the first trimester the weight gain should be minimal. Additional

Table 1. Classification of obesity based on body mass index.

Classification of Obesity	BMI
UNDERWEIGHT	< 18.5
NORMAL WEIGHT	18.5 – 24.9
OVERWEIGHT	25.0 – 29.9
OBESITY type I	30.0 – 34.9
OBESITY type II	35.0 – 39.9
OBESITY type III	> 40

Table 2. Recommended weight gain during pregnancy in relationship to woman's BMI prior to conception (Institute of Medicine, 1990).

Weight status before pregnancy	Total weight gain during pregnancy (Kgr)	Weight gain during 1st Trimester (Kgr)	Weight gain per week during 2nd and 3rd trimester (Kgr)
UNDERWEIGHT (BMI < 19.8 kgr/m^2)	12.5 – 18	2.3	0.49
NORMAL WEIGHT (BMI 19.8 – 26 kgr/m^2)	11.5 – 16	1.6	0.44
OVERWEIGHT (BMI 26 – 29 kgr/m^2)	7 – 11.5	0.9	0.3
OBESE (BMI >29 kgr/m^2)	At least 6		

energy intake is recommended during the second and third trimesters of the pregnancy. At the end of pregnancy, the 40% of the normal weight distribution in a woman with a good nutritional status corresponds to the weight of the fetus, placenta and amniotic fluid. The remaining 60% of the total weight gain corresponds to the increase in blood volume and fluid in the mother's body, as well as in the development of the uterus, breasts and energy stores (Kalhan, 2000).

Impact of Maternal Obesity in Pregnancy

Obesity during pregnancy creates a variety of issues that affect not only the mother, but the fetus and the newborn as well. Thus, this group of pregnancies is classified as high-risk one and is associated with serious maternal and perinatal complications, that make it imperative to deal promptly and effectively with it (Satpathy et, 2008).

Maternal and pregnancy complications

The problems emerging to the obese pregnant women are proportional to the degree of obesity. The prognosis and the outcome of pregnancies complicated with mild obesity, tend to be equal to those with normal weight. Women with severe obesity present difficulties and additional pregnancy problems, increasing the morbidity for the mother and the fetus. Thus, during pregnancy, there may be several serious metabolic disorders (Table 3), of which the most important are the diabetes mellitus and the hypertensive gestational disease.

Gestational diabetes mellitus is completely dependent on the degree of obesity. The most likely explanation for the increased incidence of diabetes in obese pregnant women, is that affected pregnant women are more insulin resistant than the normal ones, taking into consideration that pregnancy itself predisposes to an impaired glucose tolerance. Recently in 2013, Makela and colleagues indicated that overweight pregnant women have an increased risk of developing gestational diabetes mellitus. Furthermore, the same study found out that overweight mothers without diabetes, had higher blood glucose concentrations and increased resistance to insulin (Mäkelä et al., 2013). The incidence of fetal macrosomia in obese pregnant women corresponds to the increase of the body weight (BMI) of those, while the coexistence of gestational diabetes mellitus is additive. Fetal macrosomia appears to be significantly associated with weight gain in pregnancy as well. Recently in 2013, Black and his colleagues showed that obese pregnant women have almost twice the risk for macrosomic embryos than the overweight ones without GDM (1.65 and 2.63 respectively), while in women with normal weight and GDM the risk of fetal macrosomia was 1.96 (Black et al., 2013).

Indisputably, the majority of studies nowadays depict that obesity is associated with an increase in both blood pressure and insulin resistance. Gestational diabetes mellitus occurs more often in women with pre-existing chronic hypertension, in which there is a positive

Table 3. Complications of maternal obesity during pregnancy.

1. Gestational Diabetes Mellitus
2. Hypertensive disorder of the pregnancy
3. Preeclampsia
4. Venous thromboembolism
5. Fetal macrosomia
6. Increased risk for cesarean section
7. Abortion
8. Intrauterine death and stillbirth

Table 4. Fetal and neonatal complications of maternal obesity.

1. Sudden fetal death
2. Sudden neonatal death
3. Fetal macrosomia
4. Fetal organomegaly
5. Preterm labour
6. PPROM
7. Congenital fetal anomalies
8. Congenital heart disease
9. Newborn neurodevelopmental problems
10. Increased risk for obesity during adulthood
11. Increased risk for Diabetes Mellitus during puberty and adulthood

correlation between diastolic - systolic blood pressure and insulin resistance - glucose intolerance (Ralph, 1998). Both insulin levels and fasting glucose levels are elevated in hypertensive women, suggesting reduced insulin sensitivity (Hamasaki et al., 1996). Based on the latest data, it is currently estimated that insulin resistance is the precursor to hypertension or preeclampsia, explaining the higher rates of hypertensive disease in this category of pregnant women. This disorder occurs in the context of metabolic syndrome which often accompanies obesity and leads to atherosclerotic lesions (Dennedy et al., 2012).

Finally, thromboembolic events, urine infections and the increased risk for first trimester abortions, intra uterine death of the fetus and stillbirth, are serious complications of pregnancy that may be related to maternal obesity (Catalano and Shankar, 2017; Berggren et al., 2016).

Fetal and neonatal effects

Fetal macrosomia, unexplained fetal and neonatal death, neonatal neural tube damage, increased risk of prematurity, and others (Table 4) are the main effects most commonly associated with children born from obese mothers, comparatively with the normal-weight ones (Whitney et al., 1998). Studies indicate that overweight women who did not regulate their glucose levels and did not change their dietary habits, suffered from pregnancy associated metabolic complications, the most important of which is fetal macrosomia. This results in the birth of macrosomic infants, whose comparative study later, in the 13th month of their life, showed that they had an increased weight for their age, as well as increased BMI and insulin resistance. In many cases fetal macrosomia may be accompanied by embryo organomegaly, concerning the liver, pancreas, heart and adrenal glands, as a result of the high levels of total body protein, glycogen and fat (Uvena – Celebrezze and Catalano, 2000).

Based on the latest data, it is estimated nowadays that children of obese pregnant women have a higher risk of intra uterine and neonatal death (Tennant et al., 2011). A prospective study showed that this risk in women with a BMI> 30 kgr/m^2 is twice as high, compared to the normal - weighted (Kristensen et al., 2005). Furthermore, the increased body weight of the mother can significantly affect fetal metabolism, resulting in a higher risk of developing diabetes and cardiovascular diseases. Neonates from obese pregnant women have an increased risk in developing obesity and type I or type II diabetes in adolescence or adulthood (Boney et al., 2005). Recently in 2013, Watt and colleagues showed that the problem of obesity in childhood begins from the fetal and infant age. Women who consumed sweets, sugary soft drinks, precooked meals, and dietary supplements during pregnancy, have an increased risk of delivering overweight neonates, of about 55% (Watt et al., 2013).

It is also estimated that the higher the pregnancy weight from the beginning of pregnancy, the higher the risk for premature labor (Rahman et al., 2015; Crane et al., 2013). Recently in 2016, Faucett and colleagues

Table 5. Complications of maternal obesity regarding labor and postpartum

1.	Fetal macrosomia
2.	High percentage of cesarean section
3.	High percentage of assisted vaginal delivery
4.	Healing complications of the abdominal wound
5.	Intracranial hemorrhage of the newborn
6.	Clavicle fracture of the newborn
7.	Brachial plexus injuries of the newborn
8.	Shoulder dystocia
9.	Maternal anaimia
10.	Postpartum hemorrhage
11.	Maternal infections
12.	Thromboembolism
13.	Pulmonary embolism
14.	Difficulty in commencing breastfeeding

showed that maternal obesity is associated with an increased systemic inflammation, leading to an increased risk of premature rupture of membranes (Faucett et al., 2016). In addition, congenital heart disease, and in particular congenital malformations of the central nervous system of the neonates, such as spina bifida, anencephaly and hydrocephaly, as well as other congenital malformations (anal / rectal atresia, situs inversus, umbilical hernia, renal anomalies) are highly related to infants born from obese mothers, and especially those who also had gestational diabetes mellitus (Block et al., 2013; Best et al., 2012; Stothard et al., 2009; Waller et al., 2007).

Moreover, maternal obesity, usually accompanied by gestational diabetes mellitus, is estimated to affect neonatal neurodevelopment. Recently, Torres – Espinola and his colleagues in their effort to investigate whether the effect of maternal metabolic disorders are related to neurodevelopment activity among infants aged between 6 and 18 months, concluded that children born from overweight, obese, or mothers with gestational diabetes mellitus demonstrated significant differences in the progression of their neurodevelopmental profile, compared to those born from normal – weighted mothers (Torres – Espinola et al., 2015).

Complications in labor and postpartum

Childbirth and the immediate postpartum period in overweight and obese pregnant women, may present significant complications (Table 5). Childbirth in many cases, particularly in women with severe obesity and macrosomic embryos, is usually carried out by cesarean section (Nugent et al., 2017). Fetal macrosomia in the course of normal delivery, is associated with a high risk of injury, concerning intracranial, intraocular and intra-abdominal bleeding, fracture of the clavicle and injuries of the brachial plexus in neonates. Based on recent bibliographic data, it is estimated that percentages of invasive vaginal birth and the risk of shoulder dystocia are highly increased when attempting a normal delivery of macrosomic fetuses, especially when their weight is greater than 4500 grams (Magro – Malosso et al., 2017; Boulvain et al., 2016).

Obese pregnant women have an increased risk of developing anemia during the postpartum period, due to hemorrhage. Bodnar and colleagues indicated that the above mentioned risk is 1.8 and 2.8 times higher among women with a BMI of 28 Kgr / m^2 and 36 Kgr / m^2 respectively, compared to those with a BMI of less than 25 Kgr / m^2 (Bodnar et al., 2004). Furthermore, the increased risk of bleeding during puerperium and the higher rates of infections among obese mothers, tend to increase the length of hospitalization and consequently the costs required for their recovery (Norman et al., 2012; Robinson et al., 2005). Additionally, many early research studies demonstrate the need for chemoprophylaxis in the majority of obese pregnancies, who have a high incidence of infections postpartum, regardless the mode of delivery - vaginal or cesarean section (Moussa et al., 2016; Myles et al., 2002; Sebire et al., 2001). Another important issue is the risk of venous thrombosis and pulmonary embolism, that is estimated to be elevated in overweight and obese pregnancies who gave birth and going through the postpartum period (Catalano and Shankar, 2017; Holst et al., 2010).

Finally, obese mothers, due to the poor response of prolactin secretion to the mechanical stimulation of the nipple, report great difficulty in starting breastfeeding, as well as continuing it for a satisfactory period of time (Nohr et al., 2009). The research of Kair and Colaizy indicates that obesity may be one of the most important factors in reducing breastfeeding. At the same time, this study emphasizes in the usefulness of supporting the breastfeeding efforts among obese mothers, in order to reduce the risk of developing child obesity and preventing future diabetes in both mothers and children (Kair et al., 2015).

Table 6. Principals of prevention and management of the maternal obesity during pregnancy

1. Diet
• Macronutrients
- energy
- carbohydrates
- proteins
- fat
• Micronutrients
- vitamins
- elecrtolytes
- trace elements
2. Physical exercise
3. Bariatric surgery
4. Prophylactic administration of anticoagulants

Management of maternal obesity during pregnancy

The best and most effective treatment of obesity among pregnant women, is prevention. A healthy diet and regular physical exercise are of high importance for maintaining and improving health at all stages of a woman's life, particularly during pregnancy. In addition, other therapeutic options, such as pre-pregnancy bariatric surgery and prophylactic anticoagulation during pregnancy (Table 6), are among the main therapeutic approaches in order to reduce the obesity - associated morbidity and mortality during pregnancy.

Diet

The importance of a healthy diet during all stages of a woman's life, especially during pregnancy, is indisputable. Nutrient intake is necessary for the increased needs of a pregnant woman, concluding that nutrition plays a very important role towards a favorable pregnancy outcome. It is estimated that a good nutritional status before conception, during pregnancy and postpartum, is moreover expected to reduce the risk of birth defects and chronic diseases in children during adulthood (Kind et al., 2006; Rhind, 2004).

The research concerning the importance of nutrition during the perinatal period, is usually focused on pregnancy, particularly in the second and / or third trimester. The estimated total increase in nutritional needs, is related to the extra energy and nutrients that are required by pregnant women (Doets et al., 2008). Energy and protein-related macro-nutrient requirements are increasing during the second and third trimesters of pregnancy. More specifically, the energy-level recommendations for the third trimester range from 450 to 500 calories per day, additionally to the calories needed during the pre-pregnancy period, while protein requirements elevating more, ranging from 6 to 31 grams per day (EFSA, 2012; SACN, 2011). An unbalanced diet with deficiencies in macronutrients and micronutrients is currently estimated to be the major endometrial environmental factor that can disrupt placental and fetal growth and affect the favorable outcome of pregnancy (Berti et al., 2010; Picciano and McGuire, 2009).

In this context, it is mandatory to note, that of high importance is not only if the woman is overweight or obese before conception, but the rate of gaining weight during pregnancy as well. (Oken et al., 2009). That fact highlights the significance of commencing a pregnancy with a normal body weight and developing optimal weight loss interventions when they are needed. An overweight and particularly obese woman who wants to become pregnant must, under the guidance of the dietitian, set achievable goals. The primary concern should not be attaining an ideal body weight, but all the efforts should aim towards reducing mother’s weight, combined with improving dietary habits. Obese pregnant women should learn to choose the right foods and a diet rich in vitamins and nutrients that corresponds to the needs of the fetus. A pregnant woman is not allowed to undergo a hypocaloric diet, but it should be a reasonable choice to avoid eating particularly low-nutrient foods such as sweets, soft drinks and other low in quality but reach in calories meals. (Zhang et al., 2011).

Physical exercise

Women of childbearing age must be physically active in order to improve their nutritional and health status in general. Physical activity in pregnant women according to the type, frequency, duration and intensity, has been proven beneficial not only for the maternal health, but for the fetal and neonatal health as well (Mottola, 2009; Weissgerber et al., 2006). In contrast to sedentary lifestyle, physical exercise during pregnancy has significant benefits, such as preventing excessive maternal weight gaining, which is estimated to significantly reduce the risk of hypertensive disease of

the pregnancy, glucose intolerance and the risk of developing diabetes mellitus (Gollenberg et al., 2010; Stuebe et al., 2009; Liu et al., 2008). Furthermore, many of the usual problems related to pregnancy, such as fatigue, leg edema, insomnia, stress, anxiety and depression, are less disturbing among women attending regular exercise programs (Wolf and Mottola, 2000).

Therefore, in the absence of medical or obstetric contraindications (hypertension, pre-eclampsia, premature rupture of embryonic membranes, preterm birth history, persistent bleeding, cervical insufficiency), the American College of Obstetricians and Gynecologists suggest that pregnant women should exercise 3 to 4 times per week. The exercise program concerns 15 minutes of aerobic activity, at a specific heart rate based on age, gradually increased to a maximum of 30 minutes per exercise session. All aerobic activities should begin with 10 to 15 minutes of warm-up and followed by 10 to 15 minutes of post exercise treatment (ACOG, 2002). Recently in 2015, Bisson and his colleagues analyzing the results of their study, involving the implementation of a 12-week exercise program in obese women without pregnancy complications, concluded that a 3 – sessional exercise program every 2 weeks can keep pregnant women in good physical status, contributing to a normal progression of pregnancy, avoiding complications (Bisson et al., 2015).

Furthermore, pregnant women who did not exercise before pregnancy, should be advised to consult their physician before starting any physical activity program. Low or moderate intensity activities such as walking, swimming, running, aerobics and cycling on a static bike, are generally considered safe during pregnancy. Pregnant women should avoid diving - as the embryo is not protected in the event of decompression and embolization - and activities such as horseback riding, downhill skiing, ice hockey, cycling, as there is a possibility of losing balance and injuring the fetus (Camporesi, 1996).

Other interventions

Active weight loss interventions in obese women during pregnancy are prohibitive. Bariatric surgery could be a therapeutic option to treat obesity during the pre-conception period, bearing in mind that the required waiting period between surgery and the onset of pregnancy is at least 12 months (Maggard et al., 2008). Bariatric procedures used to reduce body weight in women with a BMI of > 30 kg / m^2, appear to improve hormonal abnormalities due to obesity and insulin resistance, contributing to the treatment of potential infertility and ensuring a more favorable outcome in pregnancy. Recently in 2014, Galazis and colleagues in their meta-analysis, indicated that in the group of women undergoing bariatric surgery, the risk of preeclampsia, diabetes mellitus and fetal macrosomia is lower than that of women in the control group. Additionally, the same study proved that there is a statistically significant increase in the risk of low birth weight of the infants, premature birth, admission of newborns to the intensive care unit and anemia in pregnant women who underwent bariatric surgery to treat obesity (Galazis et al., 2014).

Moreover, many researchers propose prophylactic anticoagulation treatment among obese pregnant women, in order to minimize the increased risk of thromboembolic events during pregnancy. The prophylactic administration of low molecular weight heparin, which is particularly important in the presence of co-existing risk factors for thromboembolic complications, should be maintained throughout the pregnancy and possibly during the puerperium, especially in those cases where pregnancy is terminated by cesarean section (Walsh and Malone, 2016; Davies et al., 2010).

CONCLUSIONS

Indisputably obesity is one of the major public health issue nowadays and is associated with many risk factors and morbidities. As it provokes many complications, obesity during pregnancy poses a variety of problems and classifies pregnant women in the high-risk pregnancy group. The impact of maternal obesity concerns not only the health of the pregnant woman and the outcome of pregnancy, but the parturition, the puerperium, and the subsequent health of the newborn and the child as well. The approach of the overweight and obese women, that should be mainly commenced during the pre-conception period, as well as the prevention of certain complications related to obesity during pregnancy, are now basic and necessary prerequisites in the contemporary obstetrics. Providing adequate information about the pregnancy and the risk factors that may affect its course from the young ages and the cultivation, before conception, of the concept of the pregnancy as a pleasant and unique state in a woman's life, may contribute the most, not only towards the pregnant woman's psychology, but enhancing the will of modern women in achieving more than one pregnancies. Furthermore, the introduction of sexual education in the teaching units of the Secondary Education along with parental support, encouraging young girls to modify or adopt specific behaviors and behavioral attitudes, should be included in the main actions of training programs, the implementation of which is estimated to contribute towards a favorable outcome of pregnancy and the future well being of children.

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