

Original Article

Investigation of the Effects of Obesity on Pregnant Women: A Systematic Review

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Abstract

Introduction: Obesity is one of the most important public health problems in both developed and developing countries. The prevalence of obesity is higher among women of childbearing potential. Obesity in pregnancy is a recognized risk factor for many maternal and neonatal adverse effects, including an increase in the rate of Cesarean sections, embryo macrosomy, and pre-eclampsia and gestation diabetes.

Purpose: The aim of this systematic literature review is to investigate the effects of obesity in pregnant women.

Methodology: A systematic search was employed in electronic databases such as MEDLINE, CINAHL, BIOMED, and ProQuest, using the following keywords: maternal obesity, effects of pregnancy (pregnancy outcomes), weight gain, prevention and prenatal complications.

Results: According to the survey results, the main health problems faced by obese and overweight women during pregnancy were diabetes mellitus, hypertension, pre-eclampsia, risk of epidural hematoma and post-natal hemorrhage. In addition, obese women more frequently experienced oligohydramnios.

Discussion: Obesity in pregnancy is one of the most provocative obstetrical problems and is linked to negative outcomes in pregnancy, for both the mother and the child alike. Diet, physical exercise and nutritional behavior of a woman during pregnancy have significant consequences for the outcome of pregnancy. However, several obese women are unaware of the health risks associated with obesity during pregnancy, and thus, may not consider a change in lifestyle during pregnancy.

Conclusions: This review indicated there is an urgent need to target obesity prevention programs to women especially those of child-bearing age in order to prevent detrimental effects on the long-term health of the mother and the infant alike. Moreover, social factors should be taken into account, such as tobacco and alcohol use, even small quantities as these are never 'innocent'. Moreover, the mental health status of the pre- and pregnant women should be safeguarded as there are a number of adverse events associated with poor outcomes for both the mother and child.

Key words: maternal obesity, pregnancy outcomes, weight gain, prevention, prenatal compli funds.

Introduction

Obesity is one of the most important public health problems in both developed and

developing countries. In 2015 there were about 400 million obese adults worldwide (Shingairai et al., 2015). This figure is estimated to reach one billion by 2030 (Wahabi et al., 2014). The

prevalence of being either overweight or obese is highest amongst women, with 63% being at reproductive age (Di et al., 2012; El-Gilany & El-Wehady, 2009). Obesity in pregnancy is a recognized risk factor for many maternal and neonatal adverse effects including an increase in the rate of cesarean sections, embryo macrosoma, pre-eclampsia and gestation diabetes (Athukorala et al., 2010; Kelly et al., 2008; Callaway et al., 2006). The number of pregnant women who are overweight or obese has increased significantly over the past decade (Kulie et al., 2011; Al-Daghri et al., 2011). The prevalence of obesity among pregnant women in the United States of America was 29.1% for 2010 (Ogden et al., 2012) and has reached 32,2% to date (Centers for Disease Control and Prevention, 2020). Maternal obesity is a serious issue facing older women. It leads to other serious problems, including hypertension, pre-eclampsia pregnancy, diabetes mellitus and sepsis, (Rowlands et al., 2010; Sebire et al., 2001). Maternal obesity is recognized to be associated with prediabetes of pregnancy. A weight gain 5 years before pregnancy has been reported to increase the risk of diabetes in pregnancy (Hedderson et al., 2008; Arendas et al., 2008). Obesity in combination with insulin resistance may contribute to hyperglycemia, hyperinsulinaemia, gestational diabetes and other perinatal effects. In obese women, birth rates with cesarean section and post-natal complications are also prevalent (Poobalan et al., 2009). Blood lipids, particularly triglycerides and hormones, such as progesterone, increase during pregnancy (Ramachenderan et al., 2008; Brizzi et al., 1999; Sattar et al., 1997). However, in obese pregnant women, the increase in triglyceride levels is accompanied by a temporary decrease in lipoprotein density (Ramsay et al., 2002). In addition, placental transfer and synthesis of lipids in women with obesity and hyperlipidaemia may also cause disturbances in fetal development (Catalano, 2007; Robertson & Sprecher, 1968).

Aim of this study was to investigate the effects of obesity on pregnant women using a systematic literature review.

Material and Methods

This systematic literature review used the relevant international literature in electronic

databases (MEDLINE, CINAHL, BIOMED and ProQuest), via various combinations of the following keywords: maternal obesity, maternal metabolism (maternal metabolism) and effects of pregnancy.

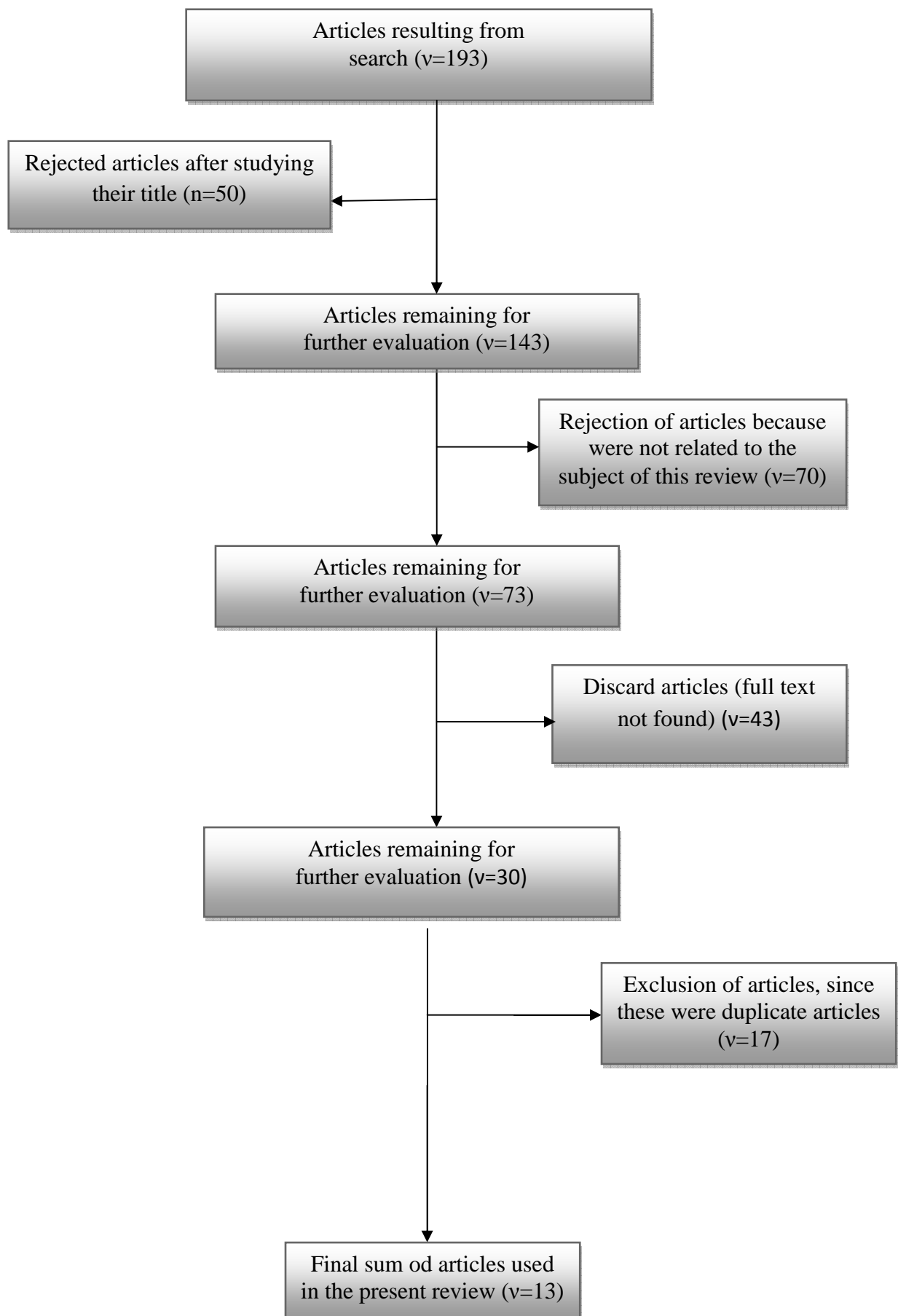
The literature review originally produced 193 articles of which 30 were rejected after perusal of their title, since they were not studies specifically related to the subject of the effects of obesity on pregnant women (figure 1). Of the remaining 163 articles, 70 were further rejected due to the following reasons:

- i) insignificant conclusions
- ii) their full results were yet to be published,
- iii) the manuscripts focused on the effects of obesity on the fetus and mother with other health problems.

Thus, the number of articles was reduced to 93. In addition, 23 articles were unavailable for full text and were therefore excluded, i.e. reducing the number to 77. After reading the full text, 17 articles were rejected, since they were duplicated studies, and the type of research was non-epidemiological and did not refer to human population but to mouse population, leaving 53 of them in total, which entered the evaluation process. A total of 13 articles, taken into account in this review, were finally selected in order to draw the expected results, which fulfilled the individual objectives set at the beginning of this work. It should be noted that the articles used as primary sources cover dates from 2006 to 2016. The primary sources were selected on the basis of the following inclusion criteria:

- The language of the paper was English.
- The papers were published between 2006 to 2016.
- The keywords of the articles were directly related to the conceptual content of the title of this review.
- The types of studies used were mainly systematic reviews, randomized clinical trials and cohort studies.
- Epidemiological studies involving only human populations and not experimental trials.
- The articles were published in approved scientific journals.

Figure 1: Research Process Diagram



Results

Out of the 13 articles included in the survey, 3 were US studies, 2 from Spain, 2 from Denmark and one each from China, Brazil, Indonesia, Australia and Norway. Also regarding the publication date of 8 articles were published in 2016, 2 articles in 2013, and from 1 article in

2015, 2014, 2011. All studies were published in English. Results are presented under three discrete sub-headings as follows: Effects of obesity on the pregnant woman; Effects of obesity on the fetus and the neonate; Knowledge of pregnant women on strategies to prevent obesity in pregnancy

Table 1: Effects of obesity on pregnant women

Researchers & Publication Date	Country	Sample	Study type	Aim	Findings
Bautista-Castano, I., Henriquez-Sanchez, P., Alema'n-Perez, N., Garcia-Salvador, J., Gonzalez-Quesada, A (2013)	Spain	6,558 pregnant women, who gave birth at the Maternal & Child University Hospital in 2008	Cohort	Assessment of the role of obesity impact on maternal health in early pregnancy, during pregnancy and during childbirth	In comparison with normal-weight pregnant women, obese women had a greater risk of developing diabetes mellitus during pregnancy [RR=2.13, 95% CI:1.52-2.95 and RR=2.85, 95% CI:2.01-4.04], hypertension and pre-eclampsia
Feresu, S., Wang, Y., Dickinson, S. (2015)	USA	255,773 births during 2008-2010	Descriptive study	Description of the relationship between maternal complications and obesity prior to pregnancy	-Women, who gave birth to twins (AOR-1.25,95% CI 1.17-1.33) and women who had a cesarean section (AOR-2.31, 95% CI 2.26-2.37) were more likely to be obese -There were metabolic complications due to obesity, which was significantly associated with metabolic syndrome, including pre-pregnancy diabetes and pregnancy diabetes, pre-pregnancy hypertension -Maternal obesity increased the risk of epidural and post-natal hemorrhage -The results of the survey show that maternal obesity is associated with the high risk of maternal complications
Wahabi, H.A., Fayed, A.A., Alzeidan, R.A., Mandil, A.A. (2014)	Saudi Arabia	2701 women whose data was extracted from King Khalid University Hospital	Cohort	The investigation of the effects of obesity and diabetes during pregnancy on the mother	-Adverse effects on pregnancy included high body weight at birth, macrosomia and pre-eclampsia -Multiple regression analysis was used to examine the relationship of obesity, gestation diabetes, and macrosomia and Cesarean section -44% of the sample was obese and 15% had pregnancy diabetes -63% of women with pregnancy diabetes were obese -Significant increase in macrosomia rate (p<0.001), high birth weight (p<0.001) and pre-eclampsia (p<0.001) -Obesity increased the risk of C-section, while the combination of gestation diabetes and obesity increased the risk of macrosomia

					(OR 3.45, CI 2.05-5.81)
Mamun, A., Callaway, L., O'Callaghan, M., Williams, G., Najman, J., Alati, R., Clavarino, A., Lawlor, D. (2011)	Australia	6,632 births who gave birth at Brisbane, Australia	Population based study	Examination of the relationship between obesity prior to pregnancy, excessive weight gain during pregnancy, with Cesarean section, the complications of pregnancy, premature delivery, placenta weight, and longer postnatal stay in hospital	- Women who were obese before pregnancy and women who gained excessive body weight during pregnancy were at greater risk for pregnancy complications (OR: 2.10, 1.74, 2.54), Cesarean section (OR: 1.29, 1.09, 1.54), higher birth weight, higher placental weight and longer hospital stay - Mothers who had an insufficient or fat body weight had a higher risk of premature labor, a lower risk of pregnancy complications lower neonatal body weight and lower placental weight
Bautista-Castano, I., Henriquez-Sanchez, P., Alema'n-Perez N., Garcia-Salvador, J., Gonzalez-Quesada, A. (2013)	Spain	6,558 pregnant women, who gave birth at the Maternal & Child University Hospital in 2008	Cohort	Assessment of the role of effects on the health of overweight and obese mothers in early pregnancy, during pregnancy, parturition and the characteristics of the newborn	-Overweight and obese women were at greater risk of developing pregnancy diabetes mellitus, hypertension and pre-eclampsia -Obese women also had oligohydramnios more commonly, polydrumnios and lacrimation -Infants from obese and overweight women had a greater neonatal weight and a greater risk for macrosomia -Infants from obese mothers had a higher risk of being introduced into special care facilities
Bjørke-Monsen A., Ulvik A., Nilsen R., Midttun O., Roth C., Magnus P., Stoltenberg, C., Vollset, S., Reichborn-Kjennerud, T., Ueland, TM (2016)	Norway	2,797 pregnant women	Cohort	Exploration of the relationship between the Body Mass Index prior to pregnancy, vitamin B levels and inflammation indices in a group of healthy pregnant women	- Pre-pregnancy BMI was associated negatively with folic acid, cobalamin and riboflamine -Inflammation appeared to be an independent prognostic index of low vitamin B6 -High pre-pregnancy BMI appeared to be a risk factor for low vitamin B levels and increased cellular inflammation -Lower vitamin B levels contributed to the adverse effects of pregnancy and were associated with maternal obesity
Molyneaux, E., Poston, L., Khondoker, M., Howard, L.M. (2016)	United Kingdom	13,314 pregnant women	Longitudinal	Investigation of a high BMI relationship prior to pregnancy and depression, and whether BMI and depression interact with increasing body weight during pregnancy	-Obese women had a significantly higher chance of depression during pregnancy than pregnant women -Each unit of increase in the Body Mass Index prior to pregnancy was associated with approximately 3% more depression possibilities prior to pregnancy before parturition
Savitri, A.I., Zuithoff, P., Browne, J.L., Amelia, D., Baharuddin, D., Grobbee, D.E. (2016)	Indonesia	2,252 pregnant women, from Budi Kemulliaan Hospital	Cohort	An assessment of whether the BMI prior to pregnancy determines blood pressure throughout pregnancy and to investigate the role of weight gain prior to pregnancy in the occurrence of hypertension during pregnancy and	- BMI, systolic and diastolic pressure increased by 0.99mm Hg/month and 0.46mm Hg/month, respectively -The highest Body Mass Index prior to pregnancy was associated with the highest systolic pressure during pregnancy (0.25mm Hg.kg/m ² , 95% CI 0.17-0.34, p<0.01) and higher diastolic blood pressure (0.18m Hg/kg/m ² , 95% CI 0.13-0.24, p<0.01)

				<p>preeclampsia</p> <p>Investigation of the correlation of maternal BMI prior to pregnancy and weight gain during pregnancy with breastfeeding at the age of 3 months</p>	<p>-Every 1 kg/m² higher Body Mass Index prior to pregnancy was associated with a 6% and 9% higher rate for gestation hypertension and preeclampsia</p> <p>-However, it appeared that the Body Mass Index prior to pregnancy determines the level, but not the change in blood pressure during pregnancy, as well as a relationship to pre-eclampsia and pregnancy hypertension, regardless of weight gain during pregnancy</p>
Castillo, H., Santos, I.S., Matijasevich, A. (2016)	Brasil	4,231 children, followed at birth, and at 3, 12, 24, 48 months after birth	Cohort		-Increased potential for weaning of infants before the age of 3 months, compared to infants from mothers with normal body weight
Pan, Y., Zhang, S., Wang, Q., Shen, H., Zhang, Y., Li, Y., Yan, D., Sun, L. (2016)	China	536,098 pregnant women, data were extracted from the National Free Preconception Health Examination Project	Cohort	Provision of basic data on the nutritional status of mothers prior to pregnancy in order to establish a correlation between maternal BMI prior to pregnancy and adverse effects during pregnancy	<p>-The prevalence of obesity increased from 13.52% to 17.2% in women aged 21-24 and from 10.72% to 13.71% in age group 25-34</p> <p>-Body weight below the normal range was associated with the birth of premature infants, low neonatal body weight and elimination</p> <p>-Overweight women had an increased risk of low neonatal body weight, while obese women had a higher risk of low neonatal body weight, abortion, ectopic pregnancy and stillborn</p> <p>- Abnormal pre-pregnancy BMI was associated with the increased risk of adverse effects of pregnancy and in particular obese women prior to pregnancy appeared to be at greater risk of developing undesirable effects of pregnancy.</p>
Hilden, K., Hanson, U., Persson, M., Fadl, H. (2016)	Sweden	13,057 pregnant women, who had been diagnosed with diabetes during pregnancy.	Cohort	Analysis of the effects of overweight and obesity on fetal macrosomia in women treated for gestational diabetes	<p>-Overweight and obesity had the same effect on the risk of Cesarean section and fetal macrosomy, but the effect of the parent BMI on the risk of pre-eclampsia was less pronounced in women with gestational diabetes</p> <p>-Women with normal body weight and gestational diabetes had an increased risk of Cesarean section, pre-eclampsia and older gestational age</p> <p>-The risk was similar in the group of overweight women without gestational diabetes, cesarean section, pre-eclampsia and older gestational age</p>
Ryckman, K.K., Donovan, B.M., Fleener, D.K., Bedell, B., Borowski, K.S. (2016)	USA	39 pregnant women (n=15, intervention group and n=24, control group)	Population based	Assessment of the difference in amino acid and fatty acid binders during pregnancy in women with and without obesity	<p>-There were significant changes in the metabolites of amino acids and carnitine between the second and third trimesters of pregnancy (p<0.002)</p> <p>-Several metabolites were marginally associated with maternal body weight, maternal glucose and maternal body weight</p>

<p>Carlhäll, S., Bladh, M., Brynhildsen, J., Claesson, I.M., Josefsson, A., Sydsjö, G., Thorsell, A., Blomberg, A. (2016)</p>	<p>Sweden</p>	<p>304 pregnant women who were divided in three subgroups, depending on the increase of their weight during pregnancy</p>	<p>Cohort</p>	<p>Assessment of whether maternal serum leptin levels are associated with the different degree of maternal obesity and weight gain in pregnancy</p>	<p>The increase in body weight during pregnancy was calculated on the basis of the mother's body weight at the week of birth minus body weight before pregnancy. The mean value of maternal leptin concentrations was significantly higher in women with obesity III compared to women in obesity class I. The mean value of the leptine concentrations was also significantly higher in obese Class II compared to obese Class I pregnant women. There was no significant difference between mean values in the leptin levels, as well as no significant interaction between the Body Mass Index and the increase in body weight during pregnancy. The levels of leptin during and after pregnancy were associated with the obesity class (in which pregnant women were classified), but not with the degree of weight gain during pregnancy.</p>
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Effects of obesity on the pregnant woman

According to our results, obesity is a serious medical condition affecting pregnant women in the United States as it relates to complications and health effects. Taking this into account, Feresu et al. (2015) conducted an investigation to describe the relationship between maternal complications and obesity prior to pregnancy. Using regression accounting models, data from 255,773 births were analyzed from 2008-2010 and the risk for reproductive factors, pregnancy complications and perinatal complications for overweight, obese and women of normal body weight. According to the results, women who gave birth to twins (AOR-1.25, 95% CI 1.17-1.33) and women who had a cesarean section (AOR-2.31, 95% CI 2.26-2.37) were more likely to be obese. There were metabolic complications due to obesity, which were significantly associated with metabolic syndrome, including pre-pregnancy diabetes and pregnancy diabetes, pre-pregnancy hypertension. Therefore, maternal obesity increased the risk of epidural and post-partum hemorrhage. The results of the survey showed that maternal obesity is associated with the high risk of maternal complications.

Moreover, obesity and pregnancy diabetes during pregnancy are identified as risk factors for adverse effects, including increased likelihood of

cesarean section, macrosoma and pre-eclampsia. Wahabi et al. (2014) investigated the effects of obesity and pregnancy diabetes on the mother herself. This retrospective survey has a sample of 2,701 women, whose data were obtained from the King Khalid University Hospital and were categorized according to their Body Mass Index (obese $\geq 30\text{kg/m}^2$, non-obese $< 30\text{ kg/m}^2$). Adverse effects on pregnancy included high maternal body weight, macrosoma and pre-eclampsia. Multiple regression analysis was used to examine the relationship of obesity, gestation diabetes, and macrosomia and Cesarean section. According to the results, 44% of the sample was obese and 15% developed diabetes during pregnancy. In addition, 63% of women with pregnancy diabetes were obese. Furthermore, there was a significant increase in the rate of macrosomia ($p<0.001$), high birth weight ($p<0.001$) and pre-eclampsia ($p<0.001$). Obesity increased the risk of C-section, while the combination of gestation diabetes and obesity increased the risk of macrosomia overall (OR 3.45, CI: 2.05-5.81).

Effects of obesity on the fetus and the neonate

Along these lines Bautista-Gastama et al. (2013) evaluated the role of obesity in the health of the mother at the beginning of pregnancy, during pregnancy and during childbirth. Their cohort

study, the sample consisted of 6,558 pregnant women who had given birth at Maternal & Child University Hospital in 2008. The data obtained were compared with multi-factorial analyzes. Pregnant women were divided into two groups (normal body weight and obese). Compared to normal body weight, pregnant women had a higher risk of diabetes mellitus hypertension and pre-eclampsia during pregnancy (RR=2.13, 95% CI: 1.52-2.95 and RR=2.85; 95% CI: 2.01-4.04, 95% CI: 1.27-3.19); hypertension (RR= 2.01; 95% CI: 3.13-7.32 and RR= 4.79, 95% CI: 3.13-7.32) and pre-eclampsia (RR= 3.16; 95% CI: 1.12-8.91 and RR= 8.80, 95% CI: 3.46-22.40). Obese women also had oligohydramnios more frequently (RR= 2.02, 95% CI: 0.125-0.307), polydrane (RR= 1.76, 95% CI: 1.03-2.99) and lacrimation (RR= 1.24, 95% CI: 1.05-1.46). In addition, both groups had increased chances of having a C-section (RR= 1.36, 95% CI: 1.14-1.63 and RR=1.84, 95% CI: 1.53-2.22, respectively) and hand-operated placental extraction. Finally, infants from obese and overweight women had a greater neonatal weight and a greater risk for macrosomia. Overall, there was a marked increase in the need for special care facilities for these infants.

Poor maternal nutrition in combination with inflammation has been associated with adverse effects on pregnancy related to maternal obesity. Along these lines, Bjorke-Monsen (2016) conducted a study to investigate the relationship between Body Mass Index prior to pregnancy, vitamin B levels and inflammatory indices in a group of healthy pregnant women. In order to collect the data from the investigation, measurements of cavalamine, folic acid, riboflavin and pyridoxyl 5-phosphate were performed. In addition, metabolic markers of homocystine and methylmalonic acid were also measured. These were taken during the 18th week of gestation. The sample consisted on 2,797 pregnant women who had taken part in the Norwegian Mother and Child Cohort Study cohort study. Results showed that the Body Mass Index prior to pregnancy was negatively correlated with folic acid, cobalamin and riboflamine ($p < 0.001$). Inflammation appeared to be an independent prognostic index of low vitamin B6. However, the high Body Mass Index prior to pregnancy appeared to be a significant risk factor for low vitamin B levels and increased cell inflammation. In addition, lower vitamin B levels contributed to the adverse effects of

pregnancy and were associated with maternal obesity.

Molyneaux et al. (2016) examined the relationship between a high Body Mass Index prior to pregnancy and the presence of depression, and, whether Body Mass Index and depression interacted with increasing body weight during pregnancy. Their data came from the Aron Longitudinal Study of Parents and Children survey. Body Mass Index prior to pregnancy and depression were measured using the Edinburgh Depression Scale at weeks 18 and 32 to determine depressive symptoms. The sample consisted of 13,314 pregnant women. Results showed that obese women had a significantly higher chance of depression during pregnancy compared to those of normal body weight. Each unit of increase in Body Mass Index prior to pregnancy was associated with approximately 3% more pre-natal depression and prior to parturition (AOR 1.03, 95% CI 0.101-0.105).

Saritri et al. (2016) assessed whether Body Mass Index prior to pregnancy determines blood pressure throughout pregnancy and also investigated the role of weight gain prior to pregnancy in the occurrence of hypertension in pregnancy and pre-eclampsia. In their prospective cohort study the sample consisted of 2,252 pregnant women, monitored by Budi Kemulliaan Hospital in Indonesia, from July 2012 to April 2015. Body Mass Index prior to pregnancy was based on women's reports of body weight prior to pregnancy. Body weight gained during pregnancy was calculated as mother's weight at birth minus body weight before-pregnancy. Systolic and diastolic blood pressures were measured during pregnancy and at each visit. According to the results, both the Body Mass Index and systolic/diastolic pressure increased (0.99mm Hg/month and 0.46mm Hg/month, respectively). The highest Body Mass Index prior to pregnancy was associated with the highest systolic pressure during pregnancy (0.25mm Hg.kg/m², 95% CI 0.17-0.34, $p < 0.01$) and higher diastolic blood pressure (0.18m Hg/kg/m², 95% CI 0.13-0.0.0 24, $p < 0.01$). For each kg increase in Body Mass Index prior to pregnancy there was an associated 6% to 9% higher rate for gestational hypertension and pre-eclampsia. However, it appeared that the Body Mass Index prior to pregnancy determines the level, but not the change in blood pressure during pregnancy, as well as a relationship to pre-

eclampsia and pregnancy hypertension, regardless of weight gain during pregnancy.

Castillo et al (2016) investigated the correlation of maternal Body Mass Index prior to pregnancy and the increase of body weight during pregnancy with the duration of breast-feeding at the age of 3 months. In this prospective cohort study the sample consisted of 4,231 children, followed from birth, at 3, 12, 24 and 48 months post-partum. The mother's Body Mass Index prior to pregnancy was categorized according to the World Health Organization classification and recommendations of the Institute of Medicine 2009. The Cox Proportional Risk model was used to assess whether the Body Mass Index prior to pregnancy and the increase in body weight during pregnancy were associated with breast-feeding. According to the results, there was an increased chance of weaning infants early, i.e. before the age of 3 months, compared to infants from mothers with normal body weight.

Excessive body weight of the mother before pregnancy increases the risk of various adverse effects in pregnancy. Under this light, Pan et al. (2016) carried out an investigation to provide basic data on the nutritional status of mothers prior to pregnancy in order to assess whether maternal body mass index with adverse effects during pregnancy. In this mass prospective population survey, the sample consisted of 536,098 pregnant women whose data were derived from the National Free Preconception Health Examination Project in China. The measurements included the primary effects of pregnancy, such as early birth, low birth weight, abortion and stillbirth. In addition, single-factorial and multi-factorial regression accounting analyzes were performed to assess the relationship between the Body Mass Index prior to pregnancy and the effects on pregnancy. It appeared from the results that between 2010 and 2012 the average Body Mass Index decreased from 21.31 to 21.16, when the prevalence of overweight/obese pregnant women increased from 10.40% to 14.4%. A stratified analysis of the age variable showed that the prevalence of overweight/obese women increased from 13.52% to 17.2% aged 21-24 and from 10.72% to 13.71% in the age group 25-34. The prevalence of overweight also increased from 9.84% to 10.75% (25-34 years old) and from 17.10% to 19.20% (35-49 years old). Obesity increased from 2.17% to 2.42% and

from 4% to 4.2% among women aged 25-43 and 35-49, respectively. Body weight below the normal range was associated with the birth of preterm newborns and low neonatal body weight. Overweight women were at increased risk of low neonatal body weight, while obese women were at higher risk of low neonatal body weight, miscarriage, ectopic pregnancy and stillborn. In conclusion, the study showed that as the Body Mass Index was reduced before pregnancy, the prevalence of overweight/obese women in a large population was increasing significantly. The abnormal Body Mass Index prior to pregnancy was associated with the increased risk of adverse effects of pregnancy, in particular fat-and-fat-bearing women prior to pregnancy, appeared to be at greater risk of developing undesirable effects of pregnancy.

Hilden et al. (2016) analyzed the effects of overweight and obesity on fetal macrosomia in women treated for pregnancy diabetes. This cohort study involved 13,057 women diagnosed with pregnancy diabetes. The survey was conducted in Sweden and the sample consisted of mothers with a Body Mass Index ≥ 18.5 kg/m². Regression analysis was used to determine the maternal effects on fetal development. Overweight and obesity had the same effect on the risk of Cesarean section and fetal macrosomy, but the effect of the mother's Body Mass Index on the risk of pre-eclampsia was less pronounced in women with gestational diabetes. Women with normal body weight and gestational diabetes had an increased risk of Cesarean section (OR 1.26, 95% CI 1.16-1.37), pre-eclampsia (OR 2.03, 95% CI 1.71-2.41) and older gestational age (OR 2.22, 95% CI 2.06-2.46). In addition, the risk was similar in the group of overweight women without gestational diabetes, cesarean section (OR 1.34, 1.33-1.36), pre-eclampsia (OR 1.76, 95% CI 1.72-1.81) and of older gestational age (OR 1.76, 95% CI 1.74-1.79).

Ryckman et al. (2016) evaluated the difference in amino acid and fatty acid binders during pregnancy in women with and without obesity. In addition, interactions between bio-indicators and obesity with maternal and fetal metabolic measurements were analyzed. Overall, the survey included 39 women (n=15, intervention team and n=24, control team) who received a 15-20 week follow-ups at the University of Iowa Hospital. The results showed that there were significant changes in the metabolites of amino acids and

carnitine between the second and third trimesters of pregnancy ($p < 0.002$). In addition, several metabolites were marginally associated with body weight of birth, maternal glucose and maternal body weight.

Knowledge of pregnant women on strategies to prevent obesity in pregnancy

Maternal obesity is accompanied by complications to the mother and fetus, both during and after pregnancy. The risk seems to increase with obesity. Leptin has been considered to play a role in the development of obesity-related complications. Along these lines, Garlhall et al. (2016) carried out an investigation to assess whether maternal serum leptin levels are associated with different degrees of maternal obesity and weight gain during pregnancy. This prospective study involved women who were in obesity classes and divided into 3 groups, depending on the increase in body weight during pregnancy ($n=304$). Maternal plasma of leptin was measured at weeks 15 and 29 of gestation, and 10 weeks after parturition. The increase in body weight during pregnancy was calculated on the basis of the mother's body weight at the week of birth minus body weight before pregnancy. The mean value of maternal leptin concentrations was significantly higher in those with greater obesity compared to women who were of normal weight. The mean value of the concentrations of leptin was also significantly higher in overweight compared to obese pregnant women. In addition, there was no significant difference between the median values of leptin levels, as well as no significant interaction between Body Mass Index and an increase in body weight during pregnancy. Thus, the levels of leptin during and after pregnancy were associated with the obesity category (in which pregnant women were classified), but not the actual degree of weight gain during pregnancy.

Discussion

The prevalence of obesity among women of childbearing potential has increased dramatically over the past two decades, with one in five women in Britain being obese, prenatally (Heslehurst et al., 2010). So obesity in pregnancy is one of the most provocative obstetrical problems and is linked to negative outcomes in pregnancy, for both the mother and the child alike (Norman & Reynolds, 2011; Reynolds et al., 2013). Diet, physical exercise and nutritional behavior of a woman during pregnancy have

significant consequences for the outcome of pregnancy (National Institute for Health and Excellence, 2017). However, several obese women are unaware of the health risks associated with obesity during pregnancy, and thus, may not consider a change in lifestyle during pregnancy.

As most studies have suggested, both pre-conception and during pregnancy, obese women need frequent glucose testing, hypertension and pre-eclampsia checking. In addition, complications due to obesity, needs to be addressed early, preferably before conception per se (Bautista-Gastano et al., 2013).

Thus, according to our analysis, obese women are at higher risk for gestational diabetes, hypertension and pre-eclampsia. In addition, there are metabolic complications due to obesity, which was significantly associated with metabolic syndrome, including pre-gestational and gestational diabetes and hypertension prior to pregnancy. Maternal obesity increases the risk of epidural and postpartum hemorrhage. The same conclusion was reached by Mamun et al. (2011), who further found that women who gained weight during pregnancy had higher birth weight, higher placental weight, and longer hospitalization. In addition, studies have shown that obese women also had oligohydramnios more often, polyhydramnios, tearing while BMI before pregnancy was negatively correlated with folic acid, cobalamin and riboflavin levels (Bjorke-Monsen, 2016).

Molyneaux et al. (2016) found that obese women had significantly higher chances of depression during pregnancy than pregnant women of normal body weight, as each unit of increase in BMI before pregnancy was associated with approximately a 3% higher chance of depression. Furthermore, in the study of Pan et al. (2016), overweight women had an increased risk of low neonatal body weight, while obese women had a higher risk of low neonatal body weight, miscarriage, ectopic pregnancy and stillbirth.

Study limitations include the small number of studies included for final analysis. A further limitation was the sole inclusion of English publications, which precludes the generality of the results as there seems to be more references to be found in Chinese or Spanish literature, not yet translated in English.

Conclusions : This review indicated there is an urgent need to target obesity prevention

programs to women especially those of child-bearing age in order to prevent detrimental effects on the long-term health of the mother and the infant alike. Moreover, social factors should be taken into account, such as tobacco and alcohol use, even small quantities as these are never 'innocent'. Moreover, the mental health status of the pre- and pregnant women should be safeguarded as there are a number of adverse events associated with poor outcomes for both the mother and child.

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