

---

## SPECIAL ARTICLE

---

# Preconception Care for Obese Women

Vorapong Phupong, M.D.\*,

\* Department of Obstetrics and Gynecology, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

### ABSTRACT

Obese women increase adverse pregnancy outcomes when they get pregnant. Preconception care for obese women should be provided in order to plan for favorable pregnancy outcomes. The topics of preconception care include past history, personal history, family history, obstetric and gynecological history, and health promotion. Obese women should lose weight by 5-10%, have adequate exercise and have adequate nutrition especially folic acid before pregnancy. When pregnant, obese women should have appropriate weight gain.

**Keywords:** obesity, preconception, counseling, folic acid.

**Correspondence to:** Vorapong Phupong, M.D. Placental related diseases Research Unit, Department of Obstetrics and Gynecology, Faculty of Medicine, Chulalongkorn University, Rama IV Road, Pathumwan, Bangkok 10330, Thailand. Email: vorapong.p@chula.ac.th

**Received:** 10 June 2022, **Revised:** 18 August 2022, **Accepted:** 22 August 2022

Preconception care is defined as the process of providing biomedical, behavioral, and social health interventions to women and couples before conception occurs<sup>(1)</sup>. The objectives of preconception care are to reduce behavioral and individual and environmental factors that cause poor maternal

and child health outcomes and to improve health status in both the short and long term of maternal and child health<sup>(1)</sup>.

Obesity is defined as a body mass index of at least or more than 30 kg/m<sup>2(2)</sup>. It can be classified into 3 classes (Table 1).

**Table 1.** Body mass index categories<sup>(2)</sup>.

Category	WHO body mass index (kg/m <sup>2</sup> )
Underweight	< 18.5
Normal weight	18.5 - 24.9
Overweight	25 - 29.9
Obesity class 1	30 - 34.9
Obesity class 2	35 - 39.9
Obesity class 3	≥ 40

Preconception care looks like the process of finding the diseases in sick patients. The process includes history

taking, physical examination and laboratory investigations. At King Chulalongkorn Memorial Hospital, the laboratory

investigations for preconception care in general couples include blood group (ABO, Rh), complete blood count, syphilis (venereal disease research laboratory (VDRL) or chemiluminescent microparticle immunoassay (CMIA)), hepatitis B antigen and antibody, anti-human immunodeficiency virus (HIV), rubella IgG and hemoglobin typing. The laboratory investigations for preconception care in obese women should add investigations to finding the diseases, for example, fasting plasma glucose or hemoglobin A1c for finding diabetes mellitus.

Prepregnancy obesity increases the risk of preeclampsia, gestational hypertension (GHT), gestational diabetes mellitus (GDM), indicated and spontaneous preterm delivery, thromboembolic disease, cesarean section and fetal macrosomia. The incidence of pregnant women with obesity at King Chulalongkorn Memorial Hospital was 2.4, 5.5, 16.6, 12.6, 12.3 and 12.4% in 2016, 2017, 2018, 2019, 2020, and 2021, respectively<sup>(3)</sup>.

### Timing for preconception care

Preconception care should offer during the check-up period, on the occasion of negative pregnancy test and postpartum period or fourth trimester<sup>(4-6)</sup>. The postpartum period is a good time for postpartum care, proper contraceptive counseling, planning for the next

pregnancy, and long-term health care<sup>(4, 5)</sup>.

### Preconception care for obese women

The Center for Diseases Control (CDC) has stratified topics in preconception care. The topics include health promotion, personal history, nutrition, immunizations, infectious diseases, medical conditions, exposures, and special populations<sup>(7)</sup>.

Obese women should receive basic preconception care similar to all women but should pay attention to health promotion, previous surgery (previous cesarean section), medical conditions (DM, HT, cardiovascular disease, depression/anxiety, eating disorder), exposures (substances, medications), and disabilities<sup>(8)</sup>.

The specific aim of preconception care for obese women is to provide education regarding the risks of adverse pregnancy outcomes while obese so that they can decide whether and when to get pregnant. They should know the complications of pregnancy increase with higher prepregnancy body mass index (BMI). They should be empowered to lose weight and have exercise before pregnancy in order to reduce the risk<sup>(8)</sup>.

Like history taking, the topics for preconception care should include past history, personal history, family history, and obstetric and gynecological history. Health promotion topics should be also added (Table 2).

**Table 2.** Topics in preconception care (modified from<sup>(7)</sup>).

---

Past history
Medical conditions: diabetes mellitus, hypertension, cardiovascular disease, etc.
Infectious diseases: chlamydia, gonorrhea, HIV, syphilis, tuberculosis
Immunizations history: hepatitis B, HPV, measles, mumps, rubella tetanus, diphtheria, pertussis, varicella, COVID-19
Previous surgery: previous cesarean section, bariatric surgery
Personal history
Alcohol, tobacco, illicit substances
Family history
Known genetic conditions
Obstetric and gynecological history
Previous miscarriage
Previous preterm birth
Previous stillbirth
Uterine anomalies
Health promotion
Family planning and reproductive life plan
Weight status
Exercise
Nutrient intake: folic acid, vitamin, calcium, iodine, essential fatty acids

---

## Past history

### • **Medical conditions**

The general points for medical conditions include the pregnancy's effect on the medical conditions and the medical conditions' influence on the pregnancy course or the fetus. Some medical conditions that may worsen the pregnancy outcomes include treated or active cancer, previous peripartum cardiomyopathy, antiphospholipid antibodies, systemic lupus erythematosus and congenital heart disease<sup>(5)</sup>.

Obesity is associated with various medical conditions such as DM, and HT. The risk of embryopathies from DM can be decreased by good glycemic control. Diabetic obese women should have good glycemic control before pregnancy. Obese women with diabetes should have regular exercise as it improves glycemic control in pregnant and nonpregnant women. Women with a BMI of > 25 kg/m<sup>2</sup> and 1 risk factor for DM should be screened for DM before pregnancy<sup>(9)</sup>.

Obese women with longstanding HT should be evaluated for end-organ involvement. These include an echocardiogram to evaluate for left ventricular hypertrophy, serum creatinine and urine protein to evaluate renal disease, and an ophthalmologic study to evaluate the retina. They should be planned to change antihypertensive drugs. Some antihypertensive drugs such as angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs) should not be used during pregnancy<sup>(8)</sup>. ACEIs can cause fetal malformations when used in the second and third trimesters. These include oligohydramnios, hypochloraria, and renal dysfunction<sup>(5)</sup>. ARBs are presumed to have the same fetal effects as ACEIs<sup>(5)</sup>.

Obese women may have eating disorders such as bulimia, and depression. They should undergo screening for eating disorders and depression<sup>(8)</sup>.

### *Diabetes mellitus*

DM is the prototype of a condition for which preconception counseling is beneficial. DM is an associated risk for adverse pregnancy outcomes. If a woman maintains glucose levels close to normal, many of these complications can be avoided before conception<sup>(5)</sup>. ACOG has concluded that preconception

counseling for women with pregestational DM is beneficial and cost-effective and should be encouraged<sup>(10)</sup>.

American Diabetic Association recommends preconception care for women with DM. The guidelines advise an inventory of disease duration and related complications and clinical and laboratory examination for end-organ damage. They encourage a preconceptional hemoglobin A1c level goal below 7%<sup>(11)</sup>. Hemoglobin A1c can also forecast the risks for gestational DM and for major anomalies<sup>(12)</sup>.

A previous study found that preconception counseling improved hemoglobin A1c levels, folic acid compliance, and optimal pregnancy preparation<sup>(13)</sup>. Women with DM who undergo preconception counseling also have improved glycemic control before pregnancy and in the first trimester and experience lower rates of adverse pregnancy outcomes<sup>(14)</sup>.

### • **Infectious diseases**

Obese women should screen for infectious diseases before conception. Common infectious diseases that are usually screened are syphilis, viral hepatitis B, and HIV. If they had infectious diseases, they should receive treatment before pregnancy.

### • **Immunizations history**

Preconception counseling for obese women, similar to non-obese women, should include an assessment of immunity against common pathogens. Other immunizations may be indicated depending on health status, travel plans, and time of year<sup>(5)</sup>.

Live-virus vaccines are contraindicated during pregnancy. These vaccines include vaccines against varicella-zoster, mumps, measles, rubella, polio, chicken pox, and yellow fever. Conception should attempt 1 month or longer after live-virus vaccination<sup>(5)</sup>.

With recent infections from COVID-19, obese women should receive the COVID-19 vaccine before or during pregnancy. COVID-19 vaccines are safe for fetus due to not live-virus vaccines<sup>(15)</sup>.

Toxoid vaccines such as tetanus are suitable before and during pregnancy. Killed bacteria or viruses' vaccines are not associated with adverse fetal outcomes

and are suitable before and during pregnancy. These killed bacteria or viruses vaccines include vaccines against influenza, pneumococcus, hepatitis B, meningococcus, and rabies<sup>(5)</sup>.

- **Previous surgery**

*Previous cesarean section*

More than 50% of women with obesity will have cesarean sections, thus, a history of previous cesarean section must be identified. They should be advised to wait at least 18 months before pregnancy<sup>(8)</sup>.

*Previous bariatric surgery*

Bariatric surgery is an option for women with class III obesity (BMI > 40 kg/m<sup>2</sup>) or with class II obesity (BMI > 35 kg/m<sup>2</sup>) with medical conditions. Maternal age is also an important aspect because the time to get pregnant should be delayed for a 6-month weight loss phase of medical management and at least a 6-month postoperative phase after bariatric surgery. Women should also screen for medical conditions that are commonly associated with obesity, such as DM, HT, obstructive sleep apnea, and depression<sup>(8)</sup>.

Obese women should receive contraceptive counseling and should be informed that conception should be delayed in the initial phase of rapid weight loss (within the first postoperative year after bariatric surgery) before performing bariatric surgery. This time will ensure adequate healing time and maximize weight loss. Obese women may have a higher risk for malnutrition and small-for-gestational-age (SGA) infants when they become pregnant during the period of rapid weight loss. However, the benefits of bariatric surgery are the improvement of reproductive functions such as anovulation and polycystic ovarian syndrome and increased fertility rates<sup>(8)</sup>.

Weight loss before pregnancy is the single effective intervention to decrease medical conditions, especially DM and HT<sup>(16)</sup>. Previous studies found that bariatric surgery decreased risks of shorter gestation, GDM and excess fetal growth. But, bariatric surgery increased the risk of SGA infants, and possibly increased mortality<sup>(17, 18)</sup>.

Obese women who have a history of bariatric

surgery increase risk for nutritional deficiencies, especially with a history of diverting surgery. Obese women who have a history of a Roux-en-Y surgery should be evaluated for folate, calcium, vitamin B12, protein, and iron deficiency anemia. When they get pregnant, they should be monitored for fetal growth with an obstetric ultrasonogram during pregnancy<sup>(8)</sup>.

## **Family history**

- **Known genetic conditions**

*Thalassemia*

Thalassemia is a common single gene disorder that have disorders of globin chain synthesis. There have at least 200 million people who carry a gene for one of these hemoglobinopathies and hundreds of known mutations to cause thalassemia syndromes. The endemic areas include the Mediterranean and Southeast Asian countries. Obese women and couples in endemic areas should undergo thalassemia carrier screening. If they are the couple at risk for thalassemia syndromes, they should receive genetic counseling for preimplantation diagnosis, prenatal diagnosis and pregnancy outcomes<sup>(5, 19)</sup>.

*Neural tube defects*

The incidence of neural tube defects (NTDs) is 0.9 per 1,000 live births. They are the second most frequent structural fetal malformation. Some of NTDs are associated with gene mutations. Mutation of methylenetetrahydrofolate reductase gene (677C → T substitution) is one location associated with NTDs<sup>(5)</sup>.

A previous trial found that periconceptual folic acid treatment significantly reduced the risk for a recurrent NTDs by 72%<sup>(20)</sup>. One study also demonstrated that universal folic acid supplementation reduced the priori risk of a first NTDs<sup>(21)</sup>. Thus, all women who may become pregnant are recommended to take 400-800 micrograms/day of folic acid orally before conception and through the first trimester<sup>(22)</sup>.

## **Health promotion**

- **Family planning and reproductive life plan**

Obese women aged 35 years or older have to weigh the risks of delayed pregnancy and advancing

maternal age on aneuploidy and fertility function compared with pregnancy at the current weight. Obese women aged less than 35 years are advised to have a target weight loss for up to one year before pregnancy. Obstetricians should consider the women's age, obstetrics and gynecological history, and the intended family size when planning a prepregnancy weight loss program<sup>(8)</sup>.

• **Weight status**

Obesity has many health problems. These health problems include HT, DM, coronary artery disease and sleep disorders. Obesity also has effects on reproduction by reducing fecundity and fertility<sup>(8)</sup>.

Prepregnancy obesity increases the risk of preeclampsia, GHT, GDM, thromboembolic disease, preterm delivery, cesarean section and fetal

macrosomia<sup>(23-25)</sup>. It is essential to inform these adverse pregnancy outcomes for preconception care for women with obesity. The risk for most adverse pregnancy outcomes occurs at a BMI of 35 kg/m<sup>2</sup>. A previous study found that some pregnancy outcomes can be improved with a modest decrease in weight<sup>(26)</sup>.

Obese women are at increased risk of pregnancies affected by congenital malformations. These congenital malformations included NTDs (odds ratio (OR) 1.87, 95% confidence interval (CI) 1.62-2.15), hydrocephalus (OR 1.68, 95% CI 1.19-2.36), limb reduction (OR 1.34, 95% CI, 1.03-1.73), cardiac defects (OR 1.30, 95% CI, 1.12-1.51), and cleft lip & palate (OR 1.20, 95% CI, 1.03-1.40) (Table 3)<sup>(27)</sup>. Obese women are also at increased risk of fetal demise. The risk for stillbirth is 2.1-4.3 fold higher in obese women when compared with normal-weight women<sup>(27)</sup>.

**Table 3.** Congenital malformations in obese versus non-obese pregnant women<sup>(27)</sup>.

congenital malformations	odds ratio	95% confidence interval
neural tube defects	1.87	1.62 - 2.15
hydrocephalus	1.68	1.19 - 2.36
limb reduction	1.34	1.03 - 1.73
cardiac defects	1.30	1.12 - 1.51
cleft lip & palate	1.20	1.03 - 1.40

A previous study demonstrated the risks of adverse pregnancy outcomes by BMI group. Adverse outcomes included preeclampsia, shoulder dystocia, cesarean section, large for gestational age, birth weight > 4,500 g, stillbirth > 28 weeks and early neonatal death. All adverse outcomes increased when BMI increased<sup>(28)</sup>. Data from the United States confirmed an increased risk of cesarean section. In nulliparous women without medical conditions, the cesarean section rate was 11.4% among underweight women and increase to 42.6% in women with class III obesity (BMI > 40 kg/m<sup>2</sup>). When all women were included, the cesarean rate was 40.3% in women with class III obesity (BMI > 40 kg/m<sup>2</sup>) without risk factors, but increase to 49.2% in those with preexisting DM or GDM, 43.8% with chronic HT, and 58.8% with both HT and DM<sup>(29)</sup>.

A previous study by Schummers et al found that

modest differences in BMI were associated with a decrease in adverse pregnancy outcomes. They demonstrated that a 10% decrease in prepregnancy BMI could decrease the risk of indicated preterm birth, GDM, preeclampsia, stillbirth and macrosomia by at least 10%. These data also reveal that 20-30% differences in prepregnancy BMI would be needed to see a change in rates of shoulder dystocia, cesarean section, 48-hour neonatal intensive care unit (NICU) stay, and newborn mortality<sup>(26)</sup>.

Some adverse pregnancy outcomes associated with obesity increase during pregnancy when excessive weight gain occurs. Thus, appropriate weight gain during pregnancy should be counseled preconception because excess weight gain increases the maternal risk of complications (DM, preeclampsia, operative delivery) and increase the risk of childhood obesity.

This confirms the importance of setting ideal gestational weight gain<sup>(8)</sup>. The recommendations for ideal

gestational weight gain by prepregnancy BMI are shown in Table 4.

**Table 4.** Recommendations for total and rate of gestational weight gain by prepregnancy BMI<sup>(30)</sup>.

Prepregnancy BMI	BMI (kg/m <sup>2</sup> ) (WHO)	Total weight gain range (kgs)	Rates of weight gain 2 <sup>nd</sup> and 3 <sup>rd</sup> Trimester (Mean range in kgs/wk)
Underweight	< 18.5	12.5 - 18.0	0.51 (0.44 - 0.58)
Normal weight	18.5 - 24.9	11.5 - 16.0	0.42 (0.35 - 0.50)
Overweight	25.0 - 29.9	7.0 - 11.5	0.28 (0.23 - 0.33)
Obese (includes all classes)	≥ 30.0	5.0 - 9.0	0.22 (0.18 - 0.27)

From this information, obese women should lose weight before pregnancy. Counseling regarding diet and exercise with a focus on lifestyle and behavior modification will be sufficient for some women with obesity. Obese women should be informed to set appropriate weight loss goals before conception and emphasis optimizing health. Multimodal interventions include lifestyle modifications in diet, exercise, and behavioral change should be used to lose weight<sup>(8)</sup>. Planning a target weight loss of 5-10% is appropriate (4.5-11 kgs) for women with class II obesity (BMI > 35 kg/m<sup>2</sup>). If this is achieved, it would decrease 1 BMI class. In addition, women with class III obesity (BMI of > 40 kg/m<sup>2</sup>) or > 35 kg/m<sup>2</sup> with medical conditions should have the option of bariatric surgery<sup>(8)</sup>.

#### • Exercise

A previous study found that only 5% of participants have an exercise for 30 minutes per day<sup>(31)</sup>. Thus, women should be encouraged to have a target of 150 minutes of moderate exercise per week or 75 minutes of vigorous exercise per week and also have muscle-strengthening activities at least 2 days per week<sup>(32)</sup>.

The current recommendation suggests that all pregnant women without contraindications to exercise should have at least 30 minutes per day of moderate-intensity exercise. The study demonstrates that exercise can limit weight gain and improve

glucose tolerance in pregnant women with obesity<sup>(33)</sup>.

#### • Nutrient intake and folic acid

Obese women increase the risk of inadequate nutrient intake. Prenatal vitamins can alleviate some risks. Thus, an intake of calcium (1,000 mg/day) is recommended, either 3 times a day or once a day. Women with previous bariatric surgery, should be advised to have adequate levels of iron, folate, vitamin B12, and vitamin D. Vitamin A intake should be limited to 10,000 IU/day<sup>(8)</sup>.

One previous meta-analysis found an increased OR for NTD in obese women (OR 1.70, 95% CI 1.34-2.15) and severely obese women (OR 3.11, 95% CI 1.75-5.46)<sup>(34)</sup>. A previous study in Thailand found that preconception folic supplementation was used in only 9.7%<sup>(35)</sup>. Epidemiologic studies also demonstrated that obese women are less likely to have adequate folic acid or use nutritional supplements than normal-weight women<sup>(36)</sup>. Thus, the current recommendations are that women should receive standard folic acid supplementation of 400 micrograms per day before conception until 12 weeks of gestation and folic acid of 4 mg per day in women who have had an NTD-affected pregnancy. But the Royal College of Obstetricians and Gynaecologists (RCOG) recommends folic acid supplementation 5 mg per day for obese women<sup>(37)</sup>.

## Conclusion

In conclusion, obese women are associated

with adverse pregnancy outcomes when pregnant. Preconception care should be provided regarding the risks of adverse pregnancy outcomes while obese so that they can decide whether and when to get pregnant. They should know those complications of pregnancy increase when BMI increases and be empowered to reduce the risk by exercising and losing weight before pregnancy.

## Potential conflicts of interest

The author declares no conflicts of interest.

## References

- Meeting to develop a global consensus on preconception care to reduce maternal and childhood mortality and morbidity. Geneva: World Health Organization; 2013.
- Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser 2000;894:1-253.
- Obstetric and gynecology statistical report 2016-2021. Department of Obstetrics and Gynecology, Faculty of Medicine, Chulalongkorn University
- ACOG Committee Opinion No. 736: Optimizing postpartum care. *Obstet Gynecol* 2018;131:e140-e50.
- Cunningham FG, Lenovo KJ, Bloom SL, Dashe JS, Hoffman BL, Casey BM, et al., editors. *Williams obstetrics*. 26th ed. New York: McGraw Hill; 2022.
- Skogsdal YRE, Karlsson JA, Cao Y, Fadl HE, Tyden TA. Contraceptive use and reproductive intentions among women requesting contraceptive counseling. *Acta Obstet Gynecol Scand* 2018;97:1349-57.
- [www.cd.gov/preconception/careforwomen/index.html](http://www.cd.gov/preconception/careforwomen/index.html)
- Delcore L, Lacoursiere DY. Preconception Care of the Obese Woman. *Clin Obstet Gynecol* 2016;59:129-39.
- Jack BW, Atrash H, Coonrod DV, Moos MK, O'Donnell J, Johnson K. The clinical content of preconception care: an overview and preparation of this supplement. *Am J Obstet Gynecol* 2008;199:S266-79.
- ACOG Practice Bulletin No. 201 Summary: Pregestational diabetes mellitus. *Obstet Gynecol* 2018;132:1514-6.
- American Diabetes A. Preconception care of women with diabetes. *Diabetes Care* 2004;27 Suppl 1:S76-8.
- Hinkle SN, Tsai MY, Rawal S, Albert PS, Zhang C. HbA1c measured in the first trimester of pregnancy and the association with gestational diabetes. *Sci Rep* 2018;8:12249.
- Yamamoto JM, Hughes DJF, Evans ML, Karunakaran V, Clark JDA, Morrish NJ, et al. Community-based pre-pregnancy care programme improves pregnancy preparation in women with pregestational diabetes. *Diabetologia* 2018;61:1528-37.
- Tripathi A, Rankin J, Aarvold J, Chandler C, Bell R. Preconception counseling in women with diabetes: a population-based study in the north of England. *Diabetes Care* 2010;33:586-8.
- COVID-19 vaccines while pregnant or breastfeeding. [www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/pregnancy.html](http://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/pregnancy.html)
- ACOG practice bulletin no. 105: bariatric surgery and pregnancy. *Obstet Gynecol* 2009;113:1405-13.
- Johansson K, Stephansson O, Neovius M. Outcomes of pregnancy after bariatric surgery. *N Engl J Med* 2015;372:2267.
- Yi XY, Li QF, Zhang J, Wang ZH. A meta-analysis of maternal and fetal outcomes of pregnancy after bariatric surgery. *Int J Gynaecol Obstet* 2015;130:3-9.
- Phupong V. Prenatal diagnoses: reason for, technique and ilssue. In: Pereira E, Soria J, editors. *Handbook of Prenatal Diagnosis: Methods, Issues and Health Impacts*. New York: Nova science publisher; 2010. p. 63-93.
- Prevention of neural tube defects: results of the Medical Research Council Vitamin Study. MRC Vitamin Study Research Group. *Lancet* 1991;338:131-7.
- Czeizel AE, Dudas I. Prevention of the first occurrence of neural-tube defects by periconceptional vitamin supplementation. *N Engl J Med* 1992;327:1832-5.
- [https://www.uspreventiveservicestaskforce.org/uspstf/sites/default/files/file/supporting\\_documents/folic-acid-newsbulletin.pdf](https://www.uspreventiveservicestaskforce.org/uspstf/sites/default/files/file/supporting_documents/folic-acid-newsbulletin.pdf)
- ACOG practice bulletin No 156: Obesity in pregnancy. *Obstet Gynecol* 2015;126:e112-e26.
- Kongubol A, Phupong V. Prepregnancy obesity and the risk of gestational diabetes mellitus. *BMC Pregnancy Childbirth* 2011;11:59.
- Siega-Riz AM, Gray GL. Gestational weight gain recommendations in the context of the obesity epidemic. *Nutr Rev* 2013;71 Suppl 1:S26-30.
- Schummers L, Hutcheon JA, Bodnar LM, Lieberman E, Himes KP. Risk of adverse pregnancy outcomes by prepregnancy body mass index: a population-based study to inform prepregnancy weight loss counseling. *Obstet Gynecol* 2015;125:133-43.
- Stothard KJ, Tennant PW, Bell R, Rankin J. Maternal overweight and obesity and the risk of congenital anomalies: a systematic review and meta-analysis. *JAMA* 2009;301:636-50.
- Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. *Obstet Gynecol* 2004;103:219-24.
- LaCoursiere DY, Bloebaum L, Duncan JD, Varner MW.

- Population-based trends and correlates of maternal overweight and obesity, Utah 1991-2001. *Am J Obstet Gynecol* 2005;192:832-9.
30. Institute of Medicine. Weight gain during pregnancy: reexamining the guidelines 2009.
  31. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc* 2008;40:181-8.
  32. <http://www.cdc.gov/physicalactivity/basics/adults/index.htm>.
  33. Seneviratne SN, McCowan LM, Cutfield WS, Derraik JG, Hofman PL. Exercise in pregnancies complicated by obesity: achieving benefits and overcoming barriers. *Am J Obstet Gynecol* 2015;212:442-9.
  34. Rasmussen SA, Chu SY, Kim SY, Schmid CH, Lau J. Maternal obesity and risk of neural tube defects: a metaanalysis. *Am J Obstet Gynecol* 2008;198:611-9.
  35. Nawapun K, Phupong V. Awareness of the benefits of folic acid and prevalence of the use of folic acid supplements to prevent neural tube defects among Thai women. *Arch Gynecol Obstet* 2007;276:53-7.
  36. Mojtabai R. Body mass index and serum folate in childbearing age women. *Eur J Epidemiol* 2004;19:1029-36.
  37. Centre for Maternal and Child Enquiries/Royal College of Obstetricians and Gynaecologists. Management of Women with Obesity in Pregnancy, 2010. Available at: <http://www.rcog.org.uk/globalassets/documents/guidelines/cmacercojointguidelinemanagementwomenobesitypregnancya.pdf>.