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REVIEW ARTICLE

Guidelines and interventions for obesity during pregnancy

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ABSTRACT

Background: Obesity is a growing worldwide epidemic among women of reproductive age, including pregnant women. The increased prevalence of obesity has been accompanied by an increase in gestational weight gain. Maternal obesity has deleterious consequences for both mother and child. *Objective:* To review the recent guidelines from the National Institute for Health and Clinical Excellence and the Institute of Medicine regarding gestational weight gain and interventions to treat obesity during pregnancy. *Methods:* Guidelines on gestational weight gain from these organizations, as well as reports of gestational weight gain in the published literature, are summarized. *Results:* Many normal and overweight parturients exceed the recommendations in the guidelines, which may contribute to postpartum obesity. *Conclusion:* Lifestyle changes, including dieting and increased activity, may help to limit excessive gestational weight gain but the optimal strategy remains unclear.

1. Introduction

Pre-conception maternal obesity affects an increasing number of women worldwide [1]. In the UK, the prevalence of women with normal body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters)—defined as 18.5–24.9—decreased from 49% in 1993 to 41% in 2008 [2]. Concurrently, the proportion of women who were obese (BMI >30) increased from 16% in 1993 to 25% in 2008 [2]. Similarly, in the USA, an estimated 35.5% of women were obese in 2007 [1], and there was a 70% increase in the number of mothers affected by pre-conception obesity between 1994 and 2003 [3]. In both countries, the increased prevalence of obesity has been accompanied by an increase in the average weight gained during pregnancy [4].

The aim of the present article was to review guidelines for the management of obesity during pregnancy: specifically, the rationale behind recent revisions to guidelines regarding the management of pre-conception BMI and gestational weight gain. In particular, we focused on modifiable behaviors such as diet and physical activity. First, the risks posed by maternal obesity during pregnancy for both mother and child are reviewed. Second, the guidelines regarding pregnancy weight and management from the National Institute for Health and Clinical Excellence (NICE) and the Institute of Medicine (IOM) are outlined. Third, we discuss how to achieve the recommended weight targets and the difficulties associated with implementing lifestyle changes in a sedentary population.

2. Risks posed by obesity during pregnancy

2.1. Maternal mortality and comorbidities

Confidential Enquiries into Maternal and Child Health (CEMACH) is an organization comprising physicians, midwives, and public health faculty in the Royal College of Physicians [5]. Data were collected from health professionals and medical record review of all maternal deaths in the UK [5]. Although maternal mortality was rare (13.1 maternal deaths per 100 000 pregnancies) during 2000–2002, CEMACH reports indicated that there was a 50% greater prenatal and peripartum mortality rate among obese mothers than among non-obese mothers [5].

In addition to maternal death, maternal pre-conception BMI has been linked to other comorbid conditions. The most common of these complications include gestational diabetes mellitus (GDM) [6], hypertensive disorders [7], and cesarean delivery [8]. In a study of women in California (n=455), women who gained 2.3–10 kg per year had a 2.5-fold increased risk of GDM compared with women whose weight remained stable [6].

In another large series (n=2947), there were 4 risk factors for pre-eclampsia [7]. The strongest risk factor was systolic blood pressure at conception, followed by pre-pregnancy BMI, number of prior induced or spontaneous abortions, and smoking history (which was protective) [7]. An increase in relative pre-pregnancy weight (defined as percentage of desired weight for height) also increased the risk for pre-eclampsia [7]. A 20% increase above the desired weight was associated with an increased risk of pre-eclampsia ($P<0.001$) [7]. In a meta-analysis, the odds of cesarean delivery increased with increasing BMI category [8].

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2.2. Fetal outcomes

Greater maternal pre-conception BMI has also been linked to adverse fetal outcomes such as spontaneous abortion, neural tube defects, and macrosomia [9,10]. Although the overall incidence of spontaneous abortion was low, a meta-analysis found that the risk was greater in obese versus non-obese women (odds ratio [OR] 3.05; 95% confidence interval [CI], 1.45–6.44) [9]. In a large cohort of infants (n = 10 249), maternal obesity increased the odds of spina bifida (OR 2.09; 95% CI, 1.63–2.70), heart defects (OR 1.26; 95% CI, 1.11–1.43), and diaphragmatic hernias (OR 1.41; 95% CI, 1.01–1.97) [10].

Infants born to obese mothers are more likely to be large for gestational age (LGA) or greater than 90th percentile for birth weight; out of 12950 deliveries, the prevalence of LGA infants was 17% among obese mothers, 12% among overweight mothers, and 11% among non-obese mothers ($P<0.01$) [11]. Pre-conception maternal obesity (OR 1.6) and pre-conception diabetes (OR 4.4) were independent risk factors for having an LGA infant [11]. The population-attributable risk for LGA is significantly larger for pre-conception maternal obesity, given that maternal obesity is more common than pre-conception diabetes [11].

Within the past decade, NICE and the IOM have issued guidelines regarding gestational weight gain. We focus on these 2 sets of guidelines because other international perinatal organizations subscribe to 1 of the 2 sets. For instance, the American Congress of Obstetricians and Gynecologists (ACOG) supports the recent IOM guideline revision. However, ACOG and the Royal College of Obstetricians and Gynaecologists (RCOG) supplement their pregnancy management guidelines with activity guidelines, which will also be reviewed briefly.

3. NICE guidelines

The IOM and NICE guidelines differ in that the former offers specific guidelines for weight gain during pregnancy based on pre-pregnancy BMI, whereas the latter recommends tips for healthful eating and activity but does not recommend specific gestational weight gain targets.

NICE recommendations include a pre-pregnancy BMI in the 18.5–24.9 range [12] (Table 1). However, pregnant women are not advised to lose weight during pregnancy. Instead, guidelines encourage women with a BMI of 30 or more at pregnancy to lose weight after delivery and before their next pregnancy [12]. NICE recommends encouraging moderate physical activity before, during, and after pregnancy [12]. If a woman has a low level of activity prior to pregnancy, the committee recommends starting with 15 minutes of light-intensity activity 3 times per week, then increasing to 30 minutes daily, as tolerated [12]. If a pregnant woman had a high level of activity prior to pregnancy, higher-intensity exercise is encouraged [12].

Although NICE recommends a low-fat diet, it does not provide specific recommendations for caloric restriction for weight loss or maintenance [13]. NICE recommends women of childbearing age and pregnant women to eat a variety of foods, including 5 servings of fruit and vegetables daily and a serving of oily fish weekly [13]. Women of childbearing age should take folic acid supplementation equivalent to 400 μg daily prior to pregnancy and during the first trimester [13]. NICE also recommends vitamin D supplementation of 10 μg daily for all pregnant women [13].

4. IOM guidelines

4.1. 1990 IOM guidelines

The 1990 IOM guidelines were based on standards for weight and height derived from Metropolitan Life Insurance tables with different BMI cutoffs for classification of underweight (<19.8), normal weight (19.8–26), overweight (26–29), and obese (>29) women than are currently accepted [4,14]. These tables were established in 1943 and recommended weights for certain heights in women based on body frame size (small, medium, and large), which was estimated by measuring elbow circumference [15]. Recommended weights were based on lowest mortality at 25–59 years of age [15]. The 2009 guidelines use BMI categories with different cutoff values, which are accepted by WHO, of 18.5, 25, and 30 [14].

4.2. 2009 IOM guideline revision

The 2009 IOM revisions were driven by changing maternal demographics—specifically, an increasing range of maternal age over the

Table 1
NICE guidelines for nutrition and activity recommendations for pre-conception and intrapartum time period based on BMI.[a]

	Pre-pregnancy BMI	
	18.5–24.9	≥25
Nutrition	Maintain a healthy weight by eating healthy starches, fiber, ≥5 servings of fruit and vegetables, low fat. Limit fried and sugary foods (fast foods) Eat breakfast	Try to lose weight before becoming pregnant by losing at most 0.5–1 kg per week Eat a balanced and healthy diet
Exercise	Do some activity every day Minimize sedentary activities Build activity into the work day Walk or bike as an alternate mode of transportation Encourage regular activity and start slowly with 15 minutes 3 times weekly, gradually increasing to 30 minutes of daily activity Encourage aerobic and strengthening exercise	
	Intrapartum BMI	
	18.5–24.9	≥25
Nutrition	Providers to discuss eating habits and address concerns Increase fruit and vegetable intake to ≥5 per day Discuss myths about how much and what to eat during pregnancy Educate that energy needs do not change much for first 6 months and then increase in last trimester by approximately 200 calories per day	Do not lose weight during pregnancy Refer to a dietician for assistance Discuss same nutrition recommendations as for pregnant women with BMI<25
Exercise	Encourage moderate activity and reassure that activity will not harm the infant Do aerobic and strengthening activities with the goal of staying fit rather than reaching maximum fitness Start slowly and gradually increase amount of exercise to goal of 30 minutes daily Women should be able to exercise at the same intensity as prior to pregnancy without any harmful effects on the mother or infant	

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); NICE, National Institute for Health and Clinical Excellence.
[a] Adapted from Ref. [12].

preceding 2 decades, as well as increasing gestational weight gain, baseline weight, and shifts in race and ethnicity among pregnant women [4]. In addition, the IOM Committee noted that the subgroups most at risk for poor maternal and fetal outcomes commonly have overweight and obese members and that recent increases in maternal age further increased comorbidity risk [4,6,7]. The 1990 gestational weight gain guidelines recommended a minimum gestational weight gain goal of at least 6 kg (15 lb) for obese women (then defined as BMI >29) and did not supply a maximum gestational weight gain goal for this subgroup [14].

The IOM evaluated data from large groups of women, birth certificates, the Pregnancy Risk Assessment Monitoring System, the Pregnancy Nutrition Surveillance System for evaluation of gestational weight gain [4], and a systematic review conducted for the Agency for Health Quality Research (AHRQ) [16]. The AHRQ report found that the most important maternal health consequences of gestational weight gain were postpartum weight retention and non-elective cesarean delivery [4,16]. Pre-eclampsia and GDM had less robust associations with prenatal weight gain [4,16]. Whereas the relationships between pre-conception BMI and both GDM [4] and hypertensive disorders [7] are well known, the relationship between these disorders and gestational weight gain is not as firmly established [4]. The AHRQ report noted that total gestational weight gain, rather than rate of gestational weight gain, was used in many studies, and the trimester of weight gain may have differential effects on maternal and fetal outcomes [16]. There was also an insufficient amount of quality data regarding gestational weight gain (either total or rate), glucose intolerance, or hypertensive disorders during pregnancy to make firm conclusions regarding the relationship between gestational weight gain and metabolic disorders of pregnancy.

The most significant child health outcomes identified by the IOM Committee included size at birth (small for gestational age and LGA), preterm birth, and childhood obesity [4]. Short-term outcomes such as fetal growth and preterm birth were noted to be significantly associated with neonatal morbidity and mortality [4]. Childhood and adolescent obesity was noted to be increasing among children in the USA since 1980, possibly increasing the risk of adult obesity [4,17]. Small for gestational age was noted to be associated with increased risk of hypoglycemia, immune dysfunction, and perinatal mortality [18]. Large for gestational age was also associated with increased risk of comorbidities for the infant as well as injuries to the mother, particularly birth traumas such as shoulder dystocia [4,9].

4.3. Summary of key differences between 1990 and 2009

The 2009 IOM report noted that pre-conception BMI independently predicted many poor pregnancy outcomes for both mother and child [4]. Therefore, the report recommended that women should have a BMI in the normal range between 18.5–24.9 prior to conception [4] (Table 2). The 2009 IOM revision differs from the 1990 guidelines in several important ways. First, the 2009 guidelines are based on observational data and WHO cutoff points for BMI categories instead of Metropolitan Life Insurance tables [4] (Table 2). Second, the more recent guidelines have a narrow range of recommended gestational weight gain for obese women, whereas the 1990 guidelines did not recommend an upper limit for gestational weight gain for this subgroup [4]. Third, frame size is no longer used as a modifier.

The revised guidelines also recommend total gestational weight gain based on pre-conception BMI such that women with normal BMI gain 11.5–16 kg on average during their pregnancy, whereas women with BMI categorized as overweight and obese gain less in total: 7–11.5 kg and 5–9 kg, respectively [4] (Table 2). Although the mean weight gain for underweight women in these databases falls within the new recommendations, some women with normal BMI and a greater proportion of women who are overweight or obese will gain more weight than is recommended by the recent gestational weight gain guidelines [4]. These data emphasize the fact that individualized interventions are needed to aid women in achieving recent guideline recommendations [4].

5. ACOG and RCOG guidelines

Although ACOG endorses IOM weight guidelines, it has developed separate recommendations for physical activity. ACOG recommends that pregnant women exercise 30 minutes daily [19]. It also recommends screening all pregnant women clinically prior to recommending an exercise program [19]. In support of the guidelines from ACOG, RCOG recommends that all women do aerobic and strength-conditioning exercise during pregnancy [20]. RCOG also recommends that women should minimize activities—such as skiing and contact sports—that risk loss of balance and fetal trauma [20]. Both organizations recommend exercise as a safe way to maintain health and vitality during pregnancy, with no known risk to the fetus or mother in most circumstances [19,20].

Physical activity before pregnancy can reduce the incidence of comorbidities during pregnancy [21,22], with greater activity before pregnancy associated with reduced odds of GDM [22,23].

There are conflicting reports regarding the association between exercise and pre-eclampsia, although a few small studies have found that regular activity in the year preceding pregnancy reduces the risk of pre-eclampsia [21] and that regular activity during early pregnancy reduces the risk of hypertensive disorders of pregnancy [24]. Physical activity has also been associated with decreased rates of cesarean delivery [25], and less anxiety and depression in the postpartum period [26]. The literature is conflicting with regard to whether physical activity during pregnancy reduces duration of labor [25], improves sleep [27], or impacts health-related quality of life [28]. However, women who exercise before and during pregnancy have less frequent nausea, heartburn, round ligament pain, and leg cramps throughout their gestation [27].

6. Implementation of gestational weight gain guidelines

Since the IOM guidelines were published, there have been several studies examining the impact of interventions on gestational weight gain, as well as prospective studies examining the effects of preconception and prenatal behaviors on pregnancy outcomes. Although the IOM guidelines are extensive in their discussion of the rationale for gestational weight gain, they include less information on how to

Table 2
IOM guidelines for total and rate of weight gain during pregnancy, based on pre-pregnancy BMI.[a,b]

Pre-pregnancy BMI	Total weight gain		Rates of weight gain during second and third trimesters	
	Range, kg	Range, lb	Mean (range), kg/wk	Mean (range), lb/wk
Underweight (<18.5)	12.5–18	28–40	0.51 (0.44–0.58)	1 (1–1.3)
Normal Weight (18.5–24.9)	11.5–16	25–35	0.42 (0.35–0.5)	1 (0.8–1)
Overweight (25–29.9)	7–11.5	15–25	0.28 (0.23–0.33)	0.6 (0.5–0.7)
Obese (≥30)	5–9	11–20	0.22 (0.17–0.27)	0.5 (0.4–0.6)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); IOM, Institute of Medicine.
[a] Adapted from Ref. [4].
[b] Calculations assume 0.5–2 kg (1.1–4.4 lb) of weight gain during the first trimester.

achieve recommended targets. The IOM first recommends that physicians educate women of childbearing age on achieving healthy weights within the normal BMI range and on the existence of the IOM guidelines on gestational weight gain prior to conception. Second, the IOM recommends using resources such as MyPyramid.gov for all pregnant women, and individualized nutrition counseling for patients exceeding gestational weight gain goals [4]. If weight gain is outside the recommendations, clinicians should evaluate for other etiologies of excessive or inadequate weight gain, specifically in terms of composition of increased weight (fat versus edema) and adequacy of fetal growth, before any alterations to pattern of weight gain are made [4].

Evidence-based strategies for optimal implementation are not currently clear. Some [29–33], but not all [29,34], studies have found a benefit from interventions to reduce gestational weight gain. In a systematic review of 10 randomized controlled and quasi-randomized controlled trials of healthy normal-weight or overweight/obese pregnant women, dietary intervention during pregnancy significantly decreased total gestational weight gain (n = 1434; weighted mean difference [WMD] −1.92 kg; 95% CI, −3.65 to −0.19; $P = 0.03$), 6-month postpartum weight retention (n = 443; WMD −1.90 kg; 95% CI, −2.69 to −1.12; $P < 0.0001$), and incidence of cesarean delivery (n = 609; relative risk 0.75; 95% CI, 0.60 to −0.94; $P = 0.013$) [29,30]. Dietary interventions during pregnancy, which varied in intensity across trials, did not have a significant effect on birth weight, pre-eclampsia, GDM, or preterm birth [29]. Although this review showed reductions in weekly and total gestational weight gain, there was no significant evidence for effects on preventing gestational weight gain above IOM guidelines, and the reduction was small (approximately 2 kg) but statistically significant [29]. In all studies in the review, all types of intervention were associated with at least a 2-kg reduction in total gestational weight gain [29]. The above-mentioned studies show that dietary education can significantly reduce gestational weight gain among pregnant women, and in some trials among overweight and obese women as well.

In addition to nutrition interventions, physical activity interventions may help to limit gestational weight gain. In a systematic review, provision of written materials and strategies to change behavior increased physical activity among patients [35]. Exercise on at least 5—if not all—days of the week is recommended by ACOG and RCOG [19]. Intensity of activity can be most conveniently estimated by using a rating of perceived exertion and ability to talk during exercise [36]; the use of maternal heart rate monitoring during activity has been questioned owing to lack of scientific data regarding correlation with intensity of activity for pregnant women [36].

Although there are many benefits associated with exercise, particularly during pregnancy, convincing women of childbearing age to exercise before and during pregnancy is difficult in a sedentary population. In addition, barriers to physical activity include other comorbidities such as joint pain and depression. Information from the Centers for Disease Control and Prevention found that, among 205 140 US adults, only 45.4% met recommendations for 30 minutes of moderate-intensity activity on 5 or more days per week [37]. These data demonstrate the difficulty in convincing the general adult population to exercise; motivating obese pregnant women to exercise daily could be an even greater challenge.

There are several patient- and provider-level factors that limit guideline implementation. Patient-level factors include patient acceptance of a weight problem and willingness to change behavior. Exercise can be physically and mentally difficult for obese pregnant women owing to lack of physical conditioning and embarrassment regarding their figures. Proper instruction on how to initiate an exercise program is imperative.

Furthermore, provider-level factors such as time restrictions and reimbursement limitations may challenge guideline implementation. There must be education of providers on the recent guidelines and instruction on how best to counsel pregnant women to make lifestyle changes. However, practitioners operate in very busy practices, and even when they have the desire to spend more time counseling patients they may not have the available time.

There are fewer studies examining how to achieve gestational weight gain guidelines specifically among overweight and obese women. In a small randomized controlled trial, Artal et al. [31] studied 96 obese women with GDM and found that a dietary and activity intervention decreased total gestational weight gain more than a dietary intervention alone (0.1 ± 0.4 kg vs 0.3 ± 0.4 kg; $P < 0.05$). These differences amounted to 0.2 kg, which—although statistically significant—was very small. In a randomized controlled trial of 360 obese pregnant women in Denmark, an intervention of dietary advice, free gym membership, and personal training significantly reduced mean gestational weight gain compared with controls: 7 kg (range, 4.7–10.6 kg) versus 8.6 kg (range, 5.7–11.5 kg) ($P = 0.01$) [33]. Furthermore, 35.4% of the intervention group exceeded the IOM gestational weight gain recommendations, compared with 46.6% of the control group ($P = 0.058$) [33]. In a case–control study in Sweden, Claesson et al. [32] evaluated 155 obese pregnant women and provided weekly motivational discussions and water aerobics classes to the intervention group, which experienced less total gestational weight gain ($P < 0.001$) and lower postpartum BMI than the control group ($P < 0.001$) [32]. The above-mentioned studies were limited by small sample sizes and highlight the fact that large randomized controlled trials are needed on limiting gestational weight gain among obese pregnant women. Furthermore, the studies reported results amounting to less than 4 kg of difference in total gestational weight gain between intervention and control groups, and therefore cannot—by themselves—remedy the increasing problem of gestational weight gain and postpartum weight retention.

The most successful interventions to prevent excessive gestational weight gain include physical activity and diet [31]; calorie goals and use of structured meal plans; and perhaps daily self-monitoring of dietary intake, frequent weight measurements, and behavioral strategies [30,38,39]. These interventions do not have to be delivered face to face. In a feasibility trial [39], telephone counseling for lifestyle change was more effective than usual care for achieving postpartum weight goals among women with lower gestational weight gain (absolute difference 22.5%; $P = 0.04$).

The effectiveness of provider-focused interventions remains untested and unknown. Ideally, increasing physical activity levels would be assisted by educating providers on counseling patients regarding exercise, providing written materials such as an exercise prescription, discussing strategies for changing activity levels [12], and teaching women warning signs to stop activity [19,20]. Exercise prescriptions have been recommended but not yet validated [35]. Similarly, restricting calories and improving dietary quality would also be assisted by provider assistance, but evidence supporting provider-based dietary counseling is lacking. There may be a lack of knowledge among healthcare providers regarding definitions of obesity based on BMI and what the guidelines recommend. A small study of 58 obstetricians, nurse practitioners, and midwives in Massachusetts, USA, found that few providers were aware of the definitions of obesity or IOM recommendations for gestational weight gain [40]. Interestingly, providers' personal factors such as self-confidence and body satisfaction were independently predictive of IOM guideline adherence [40]. Education for healthcare providers on recent guidelines for gestational weight gain may be a strategy to help pregnant women achieve gestational weight gain recommendations.

7. Conclusions and future research

Pre-conception maternal obesity is a growing epidemic and corresponds to an increase in gestational weight gain in recent decades [1,4]. NICE, IOM, and other organizations have issued guidelines on gestational weight gain, nutrition, and activity but it is not clear

how best to implement these guidelines. Although a large percentage of women of childbearing age have a BMI classified in the obese range, there is currently insufficient evidence to develop more detailed guidelines regarding gestational weight gain for these women [4]. Even though the risks of obesity to maternal and fetal health were emphasized in the IOM report, the committee found that the evidence for specific cutoffs for gestational weight gain was limited because of poor data quality. Consequently, there were only inadequate data linking gestational weight gain to maternal and child health outcomes beyond the neonatal period [4]. Further investigation of the impact of gestational weight gain on health outcomes for mother and child is needed [4]. Current research is limited by small sample sizes and few studies examining obese, rather than normal-weight and overweight, pregnant women. Because the IOM recommendations for gestational weight gain, as well as pre-conception BMI targets, are based on observational data, further randomized trials are needed to confirm the effectiveness of pre-conception weight and gestational weight gain reduction. Finally, the optimal implementation of these strategies must be tested in translational research.

Conflict of interest

The authors have no conflicts of interest.

References

[1] Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and trends in obesity among US adults, 1999–2008. JAMA 2010;303(3):235–41.
[2] National Health Service, Information Centre for Health and Social Care. Health Survey for England Trend Tables. 2009. http://www.ic.nhs.uk/pubs/hse09trends. Published 2010.
[3] American College of Obstetricians and Gynecologists. ACOG practice bulletin no. 105: bariatric surgery and pregnancy. Obstet Gynecol 2009;113(6):1405–13.
[4] Rasmussen KM, Yaktine AL, Institute of Medicine (U.S.). Committee to Reexamine IOM Pregnancy Weight Guidelines. Weight Gain During Pregnancy: Reexamining the Guidelines. Washington, DC: National Academies Press; 2009.
[5] Lewis G. Why Mothers Die 2000–2002 The Sixth Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. http://www.hqip.org.uk/assets/NCAPOP-Library/CMACE-Reports/33.-2004-Why-Mothers-Die-2000-2002-The-Sixth-Report-of-the-Confidential-Enquiries-into-Maternal-Deaths-in-the-UK.pdf. Published November 2004.
[6] Hedderson MM, Williams MA, Holt VL, Weiss NS, Ferrara A. Body mass index and weight gain prior to pregnancy and risk of gestational diabetes mellitus. Am J Obstet Gynecol 2008;198(4):409.e1–7.
[7] Sibai BM, Gordon T, Thom E, Caritis SN, Klebanoff M, McNellis D, et al. Risk factors for preeclampsia in healthy nulliparous women: a prospective multicenter study. The National Institute of Child Health and Human Development Network of Maternal-Fetal Medicine Units. Am J Obstet Gynecol 1995;172(2 Pt 1):642–8.
[8] Chu SY, Kim SY, Schmid CH, Dietz PM, Callaghan WM, Lau J, et al. Maternal obesity and risk of cesarean delivery: a meta-analysis. Obes Rev 2007;8(5):385–94.
[9] Jarvie E, Ramsay JE. Obstetric management of obesity in pregnancy. Semin Fetal Neonatal Med 2010;15(2):83–8.
[10] Waller DK, Shaw GM, Rasmussen SA, Hobbs CA, Canfield MA, Siega-Riz AM, et al. Prepregnancy obesity as a risk factor for structural birth defects. Arch Pediatr Adolesc Med 2007;161(8):745–50.
[11] Ehrenberg HM, Mercer BM, Catalano PM. The influence of obesity and diabetes on the prevalence of macrosomia. Am J Obstet Gynecol 2004;191(3):964–8.
[12] National Institute for Health and Clinical Excellence. Dietary interventions and physical activity interventions for weight management before, during and after pregnancy. http://www.nice.org.uk/nicemedia/live/13056/49926/49926.pdf. Published July 2010.
[13] National Institute for Health and Clinical Excellence. Improving the nutrition of pregnant and breastfeeding mothers and children in low-income households. http://www.nice.org.uk/nicemedia/pdf/PH011guidance.pdf. Published March 2008.
[14] Siega-Riz AM, Deierlein A, Stuebe A. Implementation of the new institute of medicine gestational weight gain guidelines. J Midwifery Womens Health 2010;55(6):512–9.
[15] Harrison GG. Height-weight tables. Ann Intern Med 1985;103(6 Pt 2):989–94.
[16] Viswanathan M, Siega-Riz AM, Moos MK, Deierlein A, Mumford S, Knaack J, et al. Outcomes of maternal weight gain. Evid Rep Technol Assess (Full Rep) 2008(168):1–223.
[17] Freedman DS, Khan LK, Serdula MK, Ogden CL, Dietz WH. Racial and ethnic differences in secular trends for childhood BMI, weight, and height. Obesity (Silver Spring) 2006;14(2):301–8.
[18] Kramer MS, Olivier M, McLean FH, Willis DM, Usher RH. Impact of intrauterine growth retardation and body proportionality on fetal and neonatal outcome. Pediatrics 1990;86(5):707–13.
[19] Committee on Obstetric Practice. ACOG committee opinion. Exercise during pregnancy and the postpartum period. Number 267, January 2002. American College of Obstetricians and Gynecologists. Int J Gynecol Obstet 2002;77(1):79–81.
[20] Royal College of Obstetricians and Gynaecologists. Exercise in Pregnancy. http://www.rcog.org.uk/files/rcog-corp/Statement4-14022011.pdf. Published January 2006.
[21] Sorensen TK, Williams MA, Lee IM, Dashow EE, Thompson ML, Luthy DA. Recreational physical activity during pregnancy and risk of preeclampsia. Hypertension 2003;41(6):1273–80.
[22] Dye TD, Knox KL, Artal R, Aubry RH, Wojtowycz MA. Physical activity, obesity, and diabetes in pregnancy. Am J Epidemiol 1997;146(11):961–5.
[23] Dempsey JC, Sorensen TK, Williams MA, Lee IM, Miller RS, Dashow EE, et al. Prospective study of gestational diabetes mellitus risk in relation to maternal recreational physical activity before and during pregnancy. Am J Epidemiol 2004;159(7):663–70.
[24] Fortner RT, Pekow PS, Whitcomb BW, Sievert LL, Markenson G, Chasan-Taber L. Physical activity and hypertensive disorders of pregnancy among Hispanic women. Med Sci Sports Exerc 2011;43(4):639–46.
[25] Melzer K, Schutz Y, Soehnchen N, Othenin-Girard V, Martinez de Tejada B, Irion O, et al. Effects of recommended levels of physical activity on pregnancy outcome. Am J Obstet Gynecol 2010;202(3):266.e1–6.
[26] Koltyn KF, Schultes SS. Psychological effects of an aerobic exercise session and a rest session following pregnancy. J Sports Med Phys Fitness 1997;37(4):287–91.
[27] Sternfeld B, Quesenberry Jr CP, Eskenazi B, Newman LA. Exercise during pregnancy and pregnancy outcome. Med Sci Sports Exerc 1995;27(5):634–40.
[28] Tendais I, Figueiredo B, Mota J, Conde A. Physical activity, health-related quality of life and depression during pregnancy. Cad Saude Publica 2011;27(2):219–28.
[29] Tanentsapf I, Heitmann BL, Adegboye AR. Systematic review of clinical trials on dietary interventions to prevent excessive weight gain during pregnancy among normal weight, overweight and obese women. BMC Pregnancy Childbirth 2011;11:81.
[30] Phelan S, Phipps MG, Abrams B, Darroch F, Schaffner A, Wing RR. Randomized trial of a behavioral intervention to prevent excessive gestational weight gain: the Fit for Delivery Study. Am J Clin Nutr 2011;93(4):772–9.
[31] Artal R, Catanzaro RB, Gavard JA, Mostello DJ, Friganza JC. A lifestyle intervention of weight-gain restriction: diet and exercise in obese women with gestational diabetes mellitus. Appl Physiol Nutr Metab 2007;32(3):596–601.
[32] Claesson IM, Sydsjö G, Brynhildsen J, Cedergren M, Jeppsson A, Nyström F, et al. Weight gain restriction for obese pregnant women: a case-control intervention study. BJOG 2008;115(1):44–50.
[33] Vinter CA, Jensen DM, Ovesen P, Beck-Nielsen H, Jørgensen JS. The LiP (Lifestyle in Pregnancy) study: a randomized controlled trial of lifestyle intervention in 360 obese pregnant women. Diabetes Care 2011;34(12):2502–7.
[34] Olson CM, Strawderman MS, Reed RG. Efficacy of an intervention to prevent excessive gestational weight gain. Am J Obstet Gynecol 2004;191(2):530–6.
[35] Paisley TS, Joy EA, Price Jr RJ. Exercise during pregnancy: a practical approach. Curr Sports Med Rep 2003;2(6):325–30.
[36] Mottola MF. Exercise prescription for overweight and obese women: pregnancy and postpartum. Obstet Gynecol Clin North Am 2009;36(2):301–16.
[37] Morbidity and Mortality Weekly Report. Prevalence of Physical Activity, Including Lifestyle Activities Among Adults – United States, 2000–2001. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5232a2.htm. Published August 15, 2003.
[38] Quinlivan JA, Lam LT, Fisher J. A randomised trial of a four-step multidisciplinary approach to the antenatal care of obese pregnant women. Aust N Z J Obstet Gynaecol 2011;51(2):141–6.
[39] Ferrara A, Hedderson MM, Albright CL, Ehrlich SF, Quesenberry Jr CP, Peng T, et al. A pregnancy and postpartum lifestyle intervention in women with gestational diabetes mellitus reduces diabetes risk factors: a feasibility randomized control trial. Diabetes Care 2011;34(7):1519–25.
[40] Herring SJ, Platek DN, Elliott P, Riley LE, Stuebe AM, Oken E. Addressing obesity in pregnancy: what do obstetric providers recommend? J Womens Health (Larchmt) 2010;19(1):65–70.