TITLE

Modern dietary guidelines for healthy pregnancy; maximising maternal and foetal outcomes and limiting excessive gestational weight gain

AUTHORS

Kirsty Jayne Elliott-Sale, Ashley Graham, Stephanie Jane Hanley, Sherry Blumenthal and Craig Sale

AFFILIATIONS

Kirsty Jayne Elliott-Sale; Musculoskeletal Physiology Research Group, Sport, Health and Performance Enhancement (SHAPE) Research Centre, School of Science and Technology, Nottingham Trent University, Clifton Lane, Clifton, Nottingham, NG11 8NS, UK. Email: kirsty.elliottsale@ntu.ac.uk. Phone: +44 (0)115 848 6338.

Ashley Graham; Musculoskeletal Physiology Research Group, Sport, Health and Performance Enhancement (SHAPE) Research Centre, School of Science and Technology, Nottingham Trent University, Clifton Lane, Clifton, Nottingham, NG11 8NS, UK. Email: ashley.graham@ntu.ac.uk. Phone: +44 (0)115 848 6338.

Stephanie Hanley; Musculoskeletal Physiology Research Group, Sport, Health and Performance Enhancement (SHAPE) Research Centre, School of Science and Technology, Nottingham Trent University, Clifton Lane, Clifton, Nottingham, NG11 8NS, UK. Email: stephanie.hanley@ntu.ac.uk. Phone: +44 (0)115 848 6338.

Sherry Blumenthal, MD, MS Ed., FACOG. Past Chair, PA Section, American Congress of Obstetricians and Gynaecologists. District III Advisory Council, American Congress of Obstetricians and Gynaecologists. Obstetric Trustee, Board of Trustees, PA Medical Society. Board member, Montgomery County Medical Society. Secretary, Philadelphia Obstetrical Society. Email: sherry.blumenthalmd@gmail.com. Phone: +1 (215) 443-0660.

Craig Sale; Musculoskeletal Physiology Research Group, Sport, Health and Performance Enhancement (SHAPE) Research Centre, School of Science and Technology, Nottingham Trent University, Clifton Lane, Clifton, Nottingham, NG11 8NS, UK. Email: craig.sale@ntu.ac.uk. Phone: +44 (0)115 848 3505.

CORRESPONDING AUTHOR

Dr Kirsty Elliott-Sale, PhD. Head of Musculoskeletal Physiology Research Group Sport, Health and Performance Enhancement (SHAPE) Research Centre, School of Science and Technology, Nottingham Trent University, Clifton Lane, Clifton, Nottingham, NG11 8NS, UK. E-mail: kirsty.elliottsale@ntu.ac.uk. Phone: +44 (0)115 848 6338.

ABSTRACT

Maternal dietary habits influence maternal and foetal health, representing a pathway for intervention to maximise pregnancy outcomes. Advice on energy intake is provided on a trimester basis, with no additional calories required in the first trimester and an additional 340 kcal·d^{-1} and 452 kcal·d^{-1} needed for the second and third trimesters. Energy intake depends on pre-gravid body mass index (BMI); underweight women are recommended an increase of 150, 200 and 300 kcal·d^{-1} during the first, second and third trimester, normal weight women an increase of 0, 350 and 500 kcal·d^{-1} and obese women an increase of 0, 450 and 350 kcal·day^{-1}. The recommendations for carbohydrate and protein intake are 175 g·d^{-1} and 0.88 - 1.1 g·kgBM·d^{-1}, with no change to fat intake. The number of pre-gravid obese women is rising; therefore, we need to regulate weight in women of childbearing age and limit gestational weight gain to within the recommended ranges [overweight women 6.8–11.3 kg and obese women 5.0–9.1 kg]. This can be achieved using nutritional interventions, as dietary changes have been shown to help with gestational weight management. As pregnancy has been identified as a risk factor for the development of obesity, normal weight women should gain 11.5-16.0 kg during pregnancy. Whilst some research has shown that dietary interventions help to regulate gestational weight gain and promote postpartum weight loss to some extent, future research is needed to provide safe and effective guidelines to maximise these effects, whist benefitting maternal and foetal health.

KEYWORDS: nutrition, health, weight

INTRODUCTION

Specific dietary practices are needed to sustain, and maximise, a healthy pregnancy and postpartum period, due to the physiological demands of gestation, childbirth and lactation. It is, therefore, important to not only consider pregnancy itself, but also the time just before pregnancy (where possible) and the months following pregnancy. Gestational nutritional guidance has been the source of much debate and often controversy, as nutritional availability and advice has changed over time, ranging from periods of famine to an obesogenic environment. The Dutch Famine Birth Cohort Study (Roseboom et al., 2001) showed that maternal undernutrition, experienced during World War II, resulted in chronic detriments in offspring health, such as cardiovascular disease, obesity, diabetes, and pulmonary disease. In addition, nutritional deficiencies have been shown to result in preterm labour and intra-uterine growth retardation (Wen, Flood, Simpson, Rissel, & Baur, 2010). Conversely, eating for two is a contemporary idiom that relates to maternal overnutrition, which is also linked with many, adverse maternal and foetal health-related outcomes (Rasmussen & Yaktine, 2009; Stotland, Cheng, Hopkins, & Caughey, 2006). There is also evidence to suggest that pre-pregnancy BMI acts as a significant predictor of adverse health related outcomes for both mother and baby (Schmitt, Nicholson & Schmitt 2007), indicating the importance of beginning pregnancy at a healthy weight. The maternal environment, and subsequent intra-uterine, foetal, environment, is an integral component of the Foetal Origins Hypothesis, which suggests that health trajectories are determined during gestation and that the effects of *in utero* programming are persistent and can remain dormant for years (Almond & Currie, 2011). The maternal supply of nutrients and oxygen has been shown to be crucial for foetal survival and adequate nutrition is necessary for healthy weight attainment (Rush, 2001). Therefore, the availability and constitution of the modern diet in relation to gestational health is extremely important and relevant.

The physiological demands of pregnancy are associated with changes in dietary energy intake (DEI) and macro- and micronutrient composition (Forsum & Löf, 2007). The guidance on gestational weight gain, and thus DEI, changed noticeably in 2002 (Institute of Medicine, 2002) and was further modified in 2004 (Butte, Wong, Treuth, Ellis, & O'Brian Smith, 2004) to reflect pre-pregnancy BMI. Macronutrient intake is often complicated by contraindicated foods (Martin et al., 2016), which have been shown to vary between countries and over time. Often women are requested to supplement essential vitamins and minerals, which may otherwise be inadequate during pregnancy compared with prenatal intake (Haider & Bhutta, 2017). Alterations in diet, especially total energy, must be conveyed in an effective and timely fashion in order to maximise maternal and foetal outcomes. This is especially true for pre-gravid obese women or women with excessive gestational weight gain, as maternal obesity is associated with a myriad of adverse effects, such as gestational diabetes, preeclampsia and preterm delivery (Dutton et al., 2018). Therefore, the aim of this review was to (1) present the energy requirements and nutritional needs of pregnancy in relation to maternal and foetal outcomes and (2) to discuss dietary interventions for gestational weight management.

ENERGY REQUIREMENTS FOR HEALTHY PREGNANCY

The need for energy and nutrients is increased slightly during pregnancy (Picciano, 2003). The body responds to the demands of pregnancy by becoming more energy efficient, through reduced habitual physical activity and lower metabolic rate, which means that only a small amount of additional energy is warranted (Ladipo, 2000). The Institute of Medicine had previously recommended that all pregnant women should increase their DEI by 300 $kcal \cdot d^{-1}$ (Institute of Medicine, 1990), although, since 2002, these recommendations have been revised to provide advice on energy intake on a trimester by trimester basis; no additional calories are required in the first trimester and an additional 340 $kcal \cdot d^{-1}$ and 452 $kcal \cdot d^{-1}$ are needed for the second and third trimesters (Institute of Medicine, 2002).

Moreover, energy intake has been further quantified based on pre-gravid BMI; underweight women are recommended an increase of 150, 200 and 300 kcal·d^{-1} during the first, second and third trimester, normal weight women an increase of 0, 350 and 500 kcal·d^{-1} and obese women an increase of 0, 450 and 350 kcal·d^{-1} (Butt et al., 2004). Therefore, pregnant women need to adapt their DEI in line with their pre-pregnancy BMI, in order to avoid or limit excessive gestational weight gain. The disregard of these guidelines has lead to pregnancy being identified as a risk factor for the development of obesity (Schmitt, Nicholson, & Schmitt, 2007) and has contributed to the rising prevalence of maternal obesity. The application of these guidelines, especially the timing of delivery, is paramount to their success and, as such, we recommend that are provided in the pre-conception period or in the first trimester of pregnancy in order to be effective.

NUTRITIONAL NEEDS FOR HEALTHY PREGNANCY

Determination of nutritional needs

The nutritional requirements of pregnancy are often difficult to define as changes in metabolism, renal function, urinary excretion and plasma volume make it difficult to determine the nutrient content of tissues and fluids. As a result of expanded plasma volume, nutrient concentrations in blood are often decreased, although total circulating quantities can be substantially increased.

Macronutrients

It is essential that the growing foetus receives sufficient amounts of energy in the form of glucose. 175 g·d^{-1} of carbohydrate is recommended during pregnancy, which is an increase of 45 g·d^{-1} compared to non-pregnant women (Brown, 2011). Diabetic pregnant women may be required to slightly reduce dietary carbohydrate intake, but non-diabetic pregnant women should not follow low-carbohydrate diets, as this puts the foetus at risk of poor growth rate, especially when a predominately low-glycaemic diet is followed (Clapp, 2002). Recent data has suggested that lower carbohydrate intake (229-429 g·d^{-1}) during the second trimester of pregnancy is associated with less gestational weight gain than moderate carbohydrate intake (430-629 g·d^{-1}) during the same period (8.03 kg compared with 10.00 kg on average; Pathirathna et al., 2017), although these carbohydrate intakes are higher than the 175 g·d^{-1} recommended by Brown (2011). That said, those with a higher carbohydrate intake (630-829 g·d^{-1}) during the second trimester of pregnancy also had a lower gestational weight gain than those with moderate carbohydrate intake (9.16 kg compared with 10.00 kg on average; Pathirathna et al., 2017). High-glycaemic diets, diets containing primarily high glycaemic types of carbohydrate, have been shown to result in excessive gestational weight gain and delivery of larger babies and placentas (Clapp, 2002). These data suggest that: 1. part of the natural variation in birth weight can be attributed to maternal carbohydrate intake, which alters circulating maternal glucose and insulin levels; 2. consuming dietary carbohydrates that elevate postprandial glucose levels increase foeto-placental growth in the second and third trimester; and 3. altering the source of maternal carbohydrate can be used to treat pregnancies at risk of abnormal foeto-placental growth.

During the second and third trimesters, an estimated 21 g·d^{-1} of protein is deposited in maternal, foetal and placental tissues (Institute of Medicine, 2002). The Institute of Medicine (2002) recommend that women consume 71 g·d^{-1} during pregnancy compared to a dietary reference intake (DRI) of 46 g·d^{-1} in non-pregnant women, whilst other recommendations suggest that pregnant women consume between 75 and 100 g·d^{-1} (Sforza Brewer & Brewer, 1985). The current Estimated Average Requirement (EAR) and Recommend Daily Allowances (RDA) for protein intake during pregnancy are calculated from factorial estimates as the nitrogen balance technique for determining protein requirement is too invasive and not appropriate for pregnant women. Elango and Ball (2016) calculated that 1.2 and 1.52 $g \cdot kgBM \cdot d^{-1}$ of protein is needed during early (~16 wk) and late (~36 wk) stages of pregnancy, which is within the acceptable macronutrient distribution range but considerably higher than other current guidelines that recommend 0.88 (EAR) and 1.1 (RDA) $g \cdot kgBM \cdot d^{-1}$ throughout pregnancy. Increased energy and protein intake has been shown to reduce the risk of pre-term birth and still-birth, low birthweight and small head circumference at birth (Ota et al, 2015). Conversely, high-protein diets, containing more than 25% of total energy intake, have been shown to provide no additional benefit to either maternal or foetal health and may, in some cases, be detrimental (Lechtig, 1975; Rush, 1989).

The DRI for fat does not change as a result of pregnancy (20-35% of total calories), however, gestational diets should include essential fatty acids, choline, sterols, phospholipids and triglycerides to support foetal growth and development (Brown, 2011). In particular, essential fatty acid intake (13 $g \cdot day^{-1}$ of omega 6 and 1.4 $g \cdot day^{-1}$ of omega 3) is important for foetal brain development, especially visual and neural development (Innis, 2008). Early gestational fat deposition has been shown to contribute to the final trimester growth spurt and lactation, which highlights the need for appropriate fat intake throughout pregnancy (Crawford, Hassman & Stevens, 1981). There is a paucity of information regarding the role of maternal fat-soluble vitamins on infant brain development, however future research is warranted to determine the impact of insufficient and excessive intake during pregnancy (Sánchez-Hernández et al., 2016). Masolva et al (2014) used data from the Danish National Birth Cohort, to investigate the relationship between fat-soluble vitamins and their influence on immunity and inflammation. They showed that during pregnancy, maternal intake of vitamin A and E may defend against child allergic rhinitis, whilst vitamin K may increase the risk of childhood asthma.

Micronutrients

During pregnancy, the need for many micronutrients rises, due to an increased number of red blood cells and greater plasma volume and reduced levels of circulating nutrient-binding proteins and micronutrients (Ladipo, 2000). Despite this, some recent data has suggested that normal pregnancy can still be associated with a decline in the dietary intakes of energy and micronutrients (Goletzke et al., 2015). In their study of 566 women participating in the Pregnancy and Glycemic Index Outcomes Study, Goletzke et al. (2015) showed that energy intake decreased in the third trimester of pregnancy and that the dietary intake of folate, iron and fibre was insufficient to meet national recommendations. Gittelsohn, Thapa & Landman (1997) have shown that inadequate intake, lack of prenatal nutritional knowledge, dietary taboos and restrictions associated with pregnancy and losses or malabsorption caused by pregnancy complications can result in micronutrient deficiencies. Such deficiencies can result in a number of adverse maternal and foetal health outcomes, such as, anaemia, resulting in maternal death (Viteri, 1994), or foetal malformations, such as neural tube defects (Gernard, 2016).

Fruit and vegetables

Many essential nutrients, such as vitamins, fibre, folate and potassium, and bioactive substances, such as flavonoids and carotenoids, are found in fruit and vegetables, which are crucial for many aspects of health. Murphy et al. (2014) examined the link between infant birth weight or small for gestational age births and maternal fruit and vegetable consumption. Eleven studies were systematically reviewed and their data included for meta-analysis. In highly developed countries, low vegetable intake was associated with small for gestational age birth and higher fruit and vegetable intake with increased birth weight. Two studies, in less developed countries, showed a relationship between increased birth weight and increased fruit or vegetable consumption. These authors concluded that, although the evidence for a protective effect of fruit and vegetable consumption on infant size was indefinite, a balanced diet including a selection of fruit and vegetables should be recommended during pregnancy. Venter et al. (2017) showed inconsistent findings from studies investigating the effects of maternal fruit and vegetable intake during pregnancy and lactation on allergic disease outcomes in offsprings. They concluded that these contrary findings may be due to the poor definition of the term "fruit and vegetable intake" and due to the large variation in the nutritional content of the fruits and vegetables investigated and that furture research is warranted that addresses these issues. In general, plant-based dietary practices, which include many types of fruit and vegetables, should be recommended during pregnancy in order to reduce the occurance of excessive gestational weight gain (Brantsaeter et al., 2014), gestation diabetes (Tryggvadottir et al., 2016) and preeclampsia (Hillesund et al., 2014). In addition, they have been associated with several positive foetal outcomes, such as reduced risk of congenital anomalies (Vujkovic et al., 2009) and favourable foetal growth (Brantsaeter et al., 2014).

Specific contraindicated foods and required supplementation

In order to avoid bacterial infections, such as salmonella and listeria, and maintain maternal and foetal health, the National Institute for Health and Care Excellence (NICE, 2017) recommend that pregnant women avoid unpasteurised milk, mould-ripened soft cheese, blue-veined cheese, pâté, uncooked or undercooked ready-prepared meals, raw or partially cooked eggs or food that may contain them and raw or partially cooked meats, especially poultry. In addition, they recommend 400 micrograms of folic acid per day, in order to reduce the risk of neural tube defects. Vitamin D (10 micrograms per day) is also advised for people at risk of vitamin D deficiency, such as women of African, African–Caribbean or South Asian origin, those with limited sun exposure, or those who cover their skin for cultural reasons. Vitamin A or routine iron supplementation is not recommended during pregnancy and foods containing high levels of vitamin A, such as liver or pate, should be avoided.

Vegetarians and vegans

Drake, Reddy and Davies (1998) showed that there were no significant differences in pregnancy outcomes or energy intakes between ovolactovegetarians (no meat but dairy and eggs), fish plus ovolactovegetarians and omnivores, despite significant differences in micronutrients levels. Similarly, Piccoli et al. (2015) showed, in a systematic review of 22 studies, that neither vegan or vegetarian diets resulted in an increased risk of negative pregnancy outcomes, with the exception of one study that showed a higher incidence of hypospadias. This review (Piccolo et al., 2015) also highlighted the contrasting evidence with regards to vegetarianism and birth weight, with five studies showing low birthweight and two studies showing high birthweight for children of vegetarian mothers. The authors concluded that the lack of randomised, controlled studies, alongside the heterogeneous and limited number of studies prevented clear conclusions on the effects of a vegan and vegetarian diet in pregnant women on birth outcomes. Based on the evidence, it would appear that vegan and vegetarian diets can be regarded as safe if supplemented with micronutrients.

DIETARY INTERVENTIONS FOR GESTATIONAL WEIGHT MANAGEMENT

Pre-gravid obesity

With 38% of the world's female population classified as obese (Ng et al., 2014), it is vital that the impact of obesity on maternal and foetal health is considered. Conception, pregnancy, labour and delivery, including surgery, are more difficult for obese women, therefore, helping these women to achieve a healthier, prenatal, weight should be part of our practice. Obesity during pregnancy can increase the risk of adverse health outcomes for both mother and baby. Studies show an increased risk of pre-eclampsia, gestational diabetes and hypertensive disorder in obese pregnant women (Kabiru & Denise Raynor, 2004), as well as increased incidence of macrosomia ((Ludwig & Currie, 2010)Dutton et al., 2018). Pre-gravid obesity can also impair foetal monitoring, leading to the need for specialised equipment, issues with anaesthesia and a greater likelihood of miscarriage (Weindling, 2003). Maternal obesity is also linked with a host of long term adverse health outcomes, such as postpartum weight retention, an unlikeness to breastfeed and childhood obesity (Fraser et al., 2011; Nehring, Schmoll, Beyerlein, Hauner, & Von Kries, 2011; Vesco et al., 2009). Recent data has also show an association between higher maternal BMI in late pregnancy and an increased risk of cardiovascular disease, type 2 diabetes and cancer in offspring (Eriksson, Sandboge, Salonen, Kajantie, & Osmond, 2014). As such, maternal obesity must be considered as a healthcare priority, due to its numerous and far-reaching effects. Moreover, the economic burden of maternal obesity must be considered as the associated costs of maternal overweight, gestational diabetes mellitus and macrosomia are substantial (Lenoir-Wijnkoop et al., 2015).

In a sense, every routine or annual visit can be considered a pre-conception visit. While it is well known that obesity is associated with the risk of anovulation and infertility (Luke, 2017), e.g., polycystic ovarian syndrome, in general, obese women have similar fecundity to those of normal BMI and are also as sexually active. There is, therefore, value in using each visit to help women achieve a healthier weight before becoming pregnant. Studies have shown that weight loss before conception is preferred and that weight loss between pregnancies also decreases the risks of of stillbirth and infant mortality (Cnattingius & Villamor, 2016). There is an obvious need, therefore, for safe and effective interventions to regulate weight in women of childbearing age and while the perception of appropriate weight has changed, and more overweight women perceive themselves as normal, presenting the issue of obesity as a health issue, not an aesthetic one, is better.

Research from the last 10 years has shown that nNutritional interventions can be effective as a means of facilitating weight management in pre-gravid obese women. Wolff, Legarth, Vangsgaard, Toubro, & Astrup (2008) showed that gestational weight gain was kept within the IOM guidelines by restricting energy intake and adopting the Danish Dietary Recommendations (fat intake: maximum 30%, protein intake 15-20%, carbohydrate intake 50-55%) in obese women. Daily energy intake, during the third trimester, was significantly different between the intervention and control groups (intervention: 1790 ± 539 kcal·d^{-1}, control: 2282 ± 411 kcal·d^{-1}), which resulted in significantly lower gestational weight gain in the intervention group (6.6 ± 5.5 kg vs. 13.3 ± 7.5 kg, mean difference 6.7 kg, 95% CI of the difference: 2.6 – 10.8 kg, P=0.002). Furthermore, no adverse effects on foetal growth were observed and fewer cases of pregnancy and birth complications (*e.g.*, gestational diabetes mellitus, pregnancy-induced hypertension) were detected in the intervention group compared to the control group.

Thornton, Smarkola, Kopacz, & Ishoof (2009) employed a balanced nutritional programme, with calorie restriction, to limit gestational weight gain in obese women. Participants were allocated into either a control or study group. Participants in the control group were counselled, on at least one occasion, regarding conventional prenatal nutrition guidelines. The study group received a more detailed dietary intake protocol, which was based on the advice given to patients with gestational diabetes mellitus. Participants were placed on an 18–24 kcal·kgBM·d^{-1} nutritionally balanced diet (40% carbohydrate, 30% protein, 30% fat) with no participant receiving a diet of less than 2000 kcal·d^{-1}.

Further to this, the study group were instructed to record all food and drink consumed each day in a diary, with the records reviewed at each prenatal visit. Gestational weight gain was significantly lower in the study group compared to the control group (5.0 ± 6.8 kg vs. 14.09 ± 7.41 kg). Furthermore, no adverse perinatal outcomes were observed, thus confirming the benefits of a well-balanced, monitored, nutritional programme in regulating gestational weight gain in obese women. Future studies should, however, consider employing more robust measures than food diaries (e.g., weighed food intake) in order to accurately record and analyse DEI.

Bogaerts et al. (2013) showed that a lifestyle intervention significantly reduced gestational weight gain in obese women when compared to a routine care group. The intervention consisted of three groups; a control group, a brochure group and a lifestyle intervention group. Women in the brochure group were given written material on a healthy lifestyle, while the lifestyle intervention group received the same written material plus four 1.5 - 2 h antenatal lifestyle intervention sessions lead by a trained midwife, focusing on the relationship between energy intake and expenditure based on the active and healthy food pyramids for pregnant women. The control group consisted of routine antenatal care. Gestational weight gain was significantly reduced in the brochure group (9.5 ± 6.8 kg) and the lifestyle intervention group (10.6 ± 7.0 kg) compared to the control group (13.5 ± 7.3 kg). Although the brochure group had greater overall reductions in gestational weight gain than the lifestyle intervention group, the percentage of women in each group that gained weight below the IOM guidelines (<5kg) was similar (brochure 27.6% and lifestyle intervention 21.1%) and was significantly greater than the control group (6.3%).

Mcgiveron et al. (2015) allocated obese women, with a BMI ≥35kg·m^2 and in their second trimester, into either an intervention group (*n*=89) or a non-intervention group (n=89). The intervention consisted of seven healthy lifestyle sessions; the focus of the session was general and pregnancy-specific nutrition guidance, food safety and the use of the Eatwell plate model (Public Health England, 2014). The non-intervention group did not attend any sessions. As a result of the intervention, gestational weight gain was significantly reduced compared to the non-intervention group (intervention 4.5 ± 4.6 kg, non-intervention 10.3 ± 4.4 kg). While 21% of the participants in the intervention group either gained no weight or lost weight during pregnancy, there were no adverse maternal or foetal health outcomes observed.

These, and other, studies have shown that nutritional intreventions can be used for gestational weight management in obese women. A systematic review of 13 studies on dietary interventions in overweight and obese pregnant women showed that gestation weight gain was reduced in nine studies (Flynn et al., 2016). They concluded that the development of clinical guidelines for dietary intervention in pre-gravid obese women is limited due to the large variation in the type of dietary interventions used.

Pregnancy as a risk factor for obesity

Pregnancy has been identified as risk factor for the development of obesity (Schmitt, Nicholson & Schmitt 2007), as a result of excessive gestational weight gain and prolonged postpartum weight retention, which is often augmented by successive pregnancies that increase the risk of further weight gain and subsequent retention. The IOM advise that underweight (pre-pregnancy body mass index [BMI] <18.5 kg·m^2) and normal weight (pre-pregnancy BMI 18.5-24.9 kg·m^2) women gain 12.5-18.0 kg and 11.5-16.0 kg during pregnancy in order to avoid excessive gestational weight gain (Rasmussen &

Yaktine, 2009). Energy intake during pregnancy is essential for supporting foetal growth and development (Barker, 1990), although the IOM have reported that many women are exceeding gestational weight gain guidelines (Institute of Medicine, 2009), often citing poor nutrition as a major contributing factor (Samura et al., 2016). Among American women, 47.5% exceeded IOM guidelines for gestational weight gain (5% and 37.6% of underweight and normal weight women; Deputy, Sharma, Kim, & Hinkle, 2015) and in the UK, 5% of women, have, at one stage in their pregnancy, attained a BMI of ≥ $35 kg \cdot m^2$ (National Obesity Observatory, 2014). These statistics clearly highlight the need to avoid excessive weight gain during pregnancy, which is retained beyond pregnancy, and the need for effective interventions to achieve this.

Luo, Dong, & Zhou (2014) showed that in normal weight Chinese women, individualised nutritional management resulted in significantly less gestational weight gain when compared to a control group receiving routine antenatal care (7.58 ± 1.59 vs. 12.57 ± 4.62 kg. $p = 0.000$). The individualised nutrition plans focussed on the inclusion of whole grains, fruits, beans and vegetables, combined with extensive obstetric care. This intervention may, however, be difficult to extrapolate to all normal weight populations, due to the highly specific Chinese diet.

In a similar approach to Luo et al., (2014), Walsh, McGowan, Mahony, Foley, & McAuliffe (2012) examined the effects of a low glycaemic index (GI) diet on Irish women during their second pregnancy. Eating a high GI diet has been shown to increase the risk of developing maternal diabetes, macrosomia and excessive gestational weight gain, while a low GI diet is associated with normal foetal growth and normal maternal weight gain (Clapp, 2002; Moses et al., 2006). Eight hundred pregnant women were randomised into either an intervention group (n=394) or control group (n=406). Women in the intervention group attended a dietary education session at 15.7 ± 3.0 week's gestation. The session focused on healthy eating, following the food pyramid, and on encouraging the inclusion of as many low GI foods as possible; i.e., exchanging high GI foods for low GI alternatives. Written material to promote the inclusion of low GI foods into their daily eucaloric diet was also issued. The control group received routine antenatal care. At 40 week's gestation, the intervention group showed significantly less gestational weight gain when compared with the control group (12.2 ±4.4 kg vs. 13.7 ± 4.9 kg, $p = 0.017$). This novel study showed that a low GI diet can result in positive maternal outcomes, namely reduced gestational weight gain, when compared to routine antenatal care. This study employed a eucaloric approach, therefore negating any issues with undernutrition.

Asbee et al. (2009) demonstrated that in women, with varying pre-pregnancy BMI's, dietary and lifestyle counselling can limit gestational weight gain. The study group received counselling on a healthy diet (40% carbohydrate, 30% protein and 30% fat) while the control group received routine antenatal care throughout pregnancy. Participants also received lifestyle counselling, wherein they were advised on appropriate weight gain during pregnancy based on the IOM guidelines and were instructed to perform physical activity throughout pregnancy, although physical activity levels were not monitored. The intervention resulted in significant reductions in gestational weight gain when compared with the control group (28.7 ± 12.5 lb vs. 35.6 ± 15.5 lb), however did not manage to increase the number of women who gained weight within the IOM guidelines (intervention: 61.4%, control: 48.8%, $p = 0.21$).

CONCLUSION

In order to sustain the physiological demands of pregnancy a balanced diet should be consumed, wherein additional calories are consumed in the second and third trimesters (340 $kcal \cdot d^{-1}$ and 452 $kcal \cdot d^{-1}$). Additional caloric consumption should be based on pre-pregnancy body mass index and adjusted accordinaly; meaning an increase of 150, 200 and 300 $kcal \cdot d^{-1}$, 0, 350 and 500 $kcal \cdot d^{-1}$ and 0, 450 and 350 $kcal \cdot day^{-1}$ per trimester for underweight, normal weight and obese women. These dietary changes should include an increase in carbohydrate and protein, but not fat, intake, in order to maximise maternal and foetal health outcomes. The rising prevalence of pre-gravid obesity, coupled with excessive gestational weight gain, means that contemporary, effective nutritional guidelines for weight management and maternal and foetal health are imperative. Appropriate gestational weight gain should be achieved through regulating maternal nutritional practices and keeping within the IOM guidelines for gestational weight gain, especially in relation to pre-pregnancy BMI and on a trimester by trimester basis. Similarly, the additional energy required to sustain a healthy viable pregnancy changes during each trimester and as a result of pre-pregnancy BMI. In the case of pre-gravid obesity, calorie guidance appears to be an effective intervention for weight management. Any nutritional intervention or dietary practice employed during pregnancy must ensure that pregnancy does not become a significant risk factor for the development of obesity in normal weight women.

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