

Nutrition in pregnancy

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Summary

A healthy and varied diet is important at all times in life, but particularly so during pregnancy. The maternal diet must provide sufficient energy and nutrients to meet the mother's usual requirements, as well as the needs of the growing fetus, and enable the mother to lay down stores of nutrients required for fetal development as well as for lactation. The dietary recommendations for pregnant women are actually very similar to those for other adults, but with a few notable exceptions. The main recommendation is to follow a healthy, balanced diet based on the *Balance of Good Health* model. In particular, pregnant women should try to consume plenty of iron- and folate-rich foods, and a daily supplement of vitamin D (10 µg/day) is recommended throughout pregnancy.

There are currently no official recommendations for weight gain during pregnancy in the UK. For women with a healthy pre-pregnancy weight, an average weight gain of 12 kg (range 10–14 kg) has been shown to be associated with the lowest risk of complications during pregnancy and labour, and with a reduced risk of having a low birthweight (LBW) infant. However, in practice, well-nourished women with a normal pre-pregnancy bodyweight show wide variations in weight gain during pregnancy. Low gestational weight gain increases the risk of having a

LBW infant, whereas excessive weight gain during pregnancy increases the risk of overweight and obesity in the mother after the birth.

A birthweight of 3.1–3.6 kg has been shown to be associated with optimal maternal and fetal outcomes for a full-term infant. LBW (birthweight <2.5 kg) is associated with increased infant morbidity and mortality, as well as an increased risk of adult diseases in later life, such as cardiovascular disease and type 2 diabetes. The fetal origins hypothesis states that chronic diseases in adulthood may be a consequence of ‘fetal programming’, whereby a stimulus or insult at a critical, sensitive period in development has a permanent effect on structure, physiology or function. However, there is little evidence that in healthy, well-nourished women, the diet can be manipulated in order to prevent LBW and the risk of chronic diseases in later life.

Maternal nutritional status at the time of conception is an important determinant of fetal growth and development, and therefore a healthy, balanced diet is important before, as well as during, pregnancy. It is also important to try and attain a healthy bodyweight prior to conception [body mass index (BMI) of 20–25], as being either underweight or overweight can affect both fertility and birth outcome. It is now well recognised that taking folic acid during the peri-conceptual period can reduce the incidence of neural tube defects (NTDs), and all women who may become pregnant are advised to take a folic acid supplement of 400 µg/day prior to and up until the 12th week of pregnancy.

The UK Committee on Medical Aspects of Food Policy (COMA) panel has established dietary reference values (DRVs) for nutrients for which there is an increased requirement during pregnancy. This includes thiamin, riboflavin, folate and vitamins A, C and D, as well as energy and protein. The energy costs of pregnancy have been estimated at around 321 MJ (77 000 kcal), based on theoretical calculations and data from longitudinal studies. In practice, individual women vary widely in metabolic rate, fat deposition and physical activity level, so there are wide variations in individual energy requirements during pregnancy. In the UK, the recommendation is that an extra 200 kcal of energy per day is required during the third trimester only. However, this assumes a reduction in physical activity level during pregnancy, and women who are underweight or who do not reduce their activity level may require more.

The COMA DRV panel did not establish any increment in requirements for any minerals during pregnancy, as physiological adaptations are thought to help meet the increased demand for minerals, *e.g.* there is an increase in absorption of calcium and iron. However, certain individuals will require more calcium, particularly teenagers whose skeletons are still developing. Up to 50% of women of childbearing age in the UK have low iron stores, and are therefore at risk of developing anaemia should they become pregnant. Moreover, around 40% of women aged 19–34 years currently have an iron intake below the lower reference nutrient intake (LRNI). Pregnant women are therefore advised to consume plenty of iron-rich foods during pregnancy and, in some cases, supplementation may be necessary.

There are a number of food safety issues that apply to women before and during pregnancy. It is advisable to pay particular attention to food hygiene during pregnancy, and to avoid certain foods (*e.g.* mould-ripened and blue-veined cheeses) in order to reduce the risk of exposure to potentially harmful food pathogens, such as

listeria and salmonella. Pregnant women, and those who may become pregnant, are also advised to avoid foods that are high in retinol (*e.g.* liver and liver products), as excessive intakes are toxic to the developing fetus. It is also recommended that the intake of both alcohol and caffeine is limited to within current guidelines.

As for the general population, pregnant women should try to consume at least two portions of fish per week, one of which should be oil-rich. However, in 2004, the Food Standards Agency (FSA) issued new advice on oil-rich fish consumption and now recommends a limit of no more than two portions of oil-rich fish per week for pregnant women (and those who may become pregnant). Oil-rich fish is a rich source of long-chain *n*-3 fatty acids which are thought to help protect against heart disease. Furthermore, these types of fatty acids are also required for fetal brain and nervous system development. The upper limit on oil-rich fish consumption is to avoid the risk of exposure to dioxins and polychlorinated biphenyls (PCBs), which are environmental pollutants. Pregnant women are also advised to avoid marlin, shark and swordfish, and limit their intake of tuna due to the risk of exposure to methylmercury, which at high levels can be harmful to the developing nervous system of the fetus.

There are certain considerations with regard to specific dietary groups during pregnancy. For example, vegetarians and vegans may have difficulty meeting their requirements for certain vitamins and minerals, particularly riboflavin, vitamin B₁₂, calcium, iron and zinc. However, most vegan and vegetarian women should be able to meet their nutrient requirements during pregnancy, with careful dietary planning, while those on very restricted diets may also need to consume fortified foods or supplements.

Pregnancy during adolescence raises a number of nutritional concerns. Teenagers already have high nutrient requirements for growth and development, and therefore there is potential competition for nutrients. Furthermore, a large proportion of teenage girls have low intakes of a range of nutrients that are important during pregnancy, particularly folate, calcium and iron. Teenagers who become pregnant often do not take folic acid supplements, either because the pregnancy is unplanned, or because they are unaware of the importance of taking folic acid. Teenage pregnancy therefore presents particular challenges for health professionals.

As well as following a healthy, balanced diet during pregnancy, staying physically active is also important, to promote general health and well-being, and also to help prevent excess maternal weight gain. Studies that have looked at the effects of maternal physical activity on pregnancy outcome have been of variable quality, but there is little evidence that moderate exercise can have any adverse effects on the health of the mother or the fetus. Studies do suggest that regular, aerobic exercise during pregnancy helps improve or maintain physical fitness and body image. It is recommended that pregnant women should continue with their usual physical activity for as long as feels comfortable, and try to keep active on a daily basis, *e.g.* by walking. Swimming is a particularly suitable form of exercise, although it is advisable to avoid strenuous or vigorous physical activity during pregnancy.

Keywords: birthweight, folic acid, food safety, oil-rich fish, pregnancy, vitamin A

I Introduction

Dietary recommendations for women before and during pregnancy are, in fact, very similar to those for other adults, but with a few exceptions. The main recommendation is to eat a healthy, balanced diet as described in the *Balance of Good Health* model. However, there are some specific recommendations which apply to pregnancy, e.g. taking folic acid supplements to help reduce the risk of neural tube defects (NTDs). There are also certain recommendations with regard to food safety, e.g. the avoidance of certain foods to minimise the risk of food poisoning from harmful bacteria.

This briefing paper will outline the physiological changes that take place during pregnancy and the influence of maternal diet and nutritional status on fetal outcome. The current UK dietary recommendations for women both prior to and during pregnancy will be discussed in detail, together with their evidence basis. Food safety issues are also covered, as well as diet-related conditions during pregnancy, such as anaemia and gestational diabetes. Issues relating to specific groups, including vegetarians and teenagers, are discussed in the final section.

2 Physiological changes during pregnancy

2.1 Changes in body composition and weight gain

Based on data from two studies of more than 3800 British women in the 1950s, Hytten and Leitch (1971) established 12.5 kg as the physiological norm for average weight gain for a full-term pregnancy of 40 weeks. On average, this level of weight gain was shown to be associated with optimal reproductive out-

come and was used as the basis for estimating components of weight changes in healthy pregnant women.

Table 1 shows that the fetus accounts for approximately 27% of the total weight gain, the amniotic fluid for 6% and the placenta for 5%. The remainder is due to increases in maternal tissues, including the uterus and mammary glands, adipose tissue (fat), maternal blood volume and extracellular fluid, but not maternal lean tissues. Approximately 5% of the total weight gain occurs in the first 10–13 weeks of pregnancy. The remainder is gained relatively evenly throughout the rest of pregnancy, at an average rate of approximately 0.45 kg per week.

Hytten and Leitch (1971) estimated that for an average weight gain of 12.5 kg, approximately 3.35 kg of fat would be stored by the mother (Table 1). Maternal fat deposition is encouraged by the hormone progesterone, secretion of which rises as much as ten-fold throughout the course of pregnancy. Fat is stored most rapidly during mid-pregnancy, while the fetus is small, and is thought to ensure a buffer of energy stores for late pregnancy and during lactation. The deposition of fat is not an obligatory requirement of pregnancy; however, in developed countries pregnant women usually deposit fat, although in highly variable amounts.

More recently, the World Health Organization (WHO) Collaborative Study on Maternal Anthropometry and Pregnancy Outcomes reviewed data on over 100 000 births from 20 countries to assess anthropometric indicators that may be associated with poor fetal outcomes, such as low birthweight (LBW) and pre-term delivery, or poor maternal outcomes, such as pre-eclampsia. The WHO review showed that a birthweight of 3.1–3.6 kg (mean 3.3 kg) was associated with optimal fetal and maternal outcomes. The range of maternal

Table 1 Components of weight gain during pregnancy

Body component	Increase in weight (kg) at 40 weeks	Percentage (%) of total weight gain
Products of conception	Fetus	27.2
	Placenta	5.2
	Amniotic fluid	6.4
Maternal tissues	Uterus	7.8
	Mammary gland	3.3
	Blood	10.0
	Extracellular; extravascular fluid	13.4
Total weight gain	12.50	100.0
Assumed fat deposition	3.35	26.8

Source: adapted from Hytten and Leitch (1971).

Table 2 The Institute of Medicine (IOM) recommended ranges for total weight gain for pregnant women

Pre-pregnancy BMI (kg/m ²)	Recommended weight gain
<19.8	12.5–18 kg
19.8–26	11.5–16 kg
>26–29	7–11.5 kg
>29	≥6 kg

Source: IOM (1990).
BMI, body mass index.

weight gains associated with this optimal birthweight was 10–14 kg, with an average weight gain of 12 kg (WHO 1995).

The amount of weight gain required during pregnancy to achieve a favourable outcome is also influenced by pre-pregnancy bodyweight. In 1990, the Institute of Medicine (IOM) in the USA published a report which re-evaluated the evidence regarding optimal weight gain during pregnancy. The report concluded that pre-pregnancy bodyweight should be taken into account when advising on optimal weight gain. The recommendations for total weight gain according to pre-pregnancy body mass index (BMI) are shown in Table 2. For women with a normal pre-pregnancy BMI, a weight gain of around 0.4 kg per week during the second and third trimesters is recommended. For underweight women, a weight gain of 0.5 kg per week is the target, whereas for overweight women, 0.3 kg per week is recommended (IOM 1990).

There are currently no official recommendations for weight gain in the UK. In practice, women who are normally of a healthy weight vary widely in the amount of weight they gain during pregnancy; the average is 11–16 kg, but the variation is large (Goldberg 2002). In cases of twin or multiple pregnancies, maternal weight gain tends to be greater overall and the pattern of weight gain seems to differ; for example, women with twins tend to gain more weight in early pregnancy (see Rosello-Soberon *et al.* 2005).

Excessive weight gain during pregnancy is associated with a number of complications which are similar to those associated with overweight and obesity (*e.g.* elevated blood pressure). Moreover, extreme weight gain during pregnancy is more likely to lead to overweight and obesity in the mother post-partum. Conversely, low gestational weight gain in women who are underweight or of normal weight prior to pregnancy is associated with the risk of having a LBW baby (Gold-

berg 2002). LBW is related to an increased risk of a number of adult diseases and this is discussed further in section 3.

It is often assumed that breastfeeding can help women to lose excess weight that has been gained during pregnancy. However, studies have shown that breastfeeding actually has a limited effect on post-partum weight and fat losses, particularly in well-nourished affluent women, and therefore not too much emphasis should be placed on breastfeeding as a means of weight control post-partum (Prentice *et al.* 1996). A number of behavioural and environmental factors appear to have an effect on post-partum weight change. For example, it has been shown that women who return to work soonest after giving birth have the greatest weight loss at 6 months, which may be due to either an increase in physical activity and/or restricted food access (Goldberg 2002).

2.2 Changes in blood composition

Plasma volume begins to rise as early as the first 6–8 weeks of pregnancy and increases by approximately 1500 ml by the 34th week. The increase in volume is related to fetal size, but not to the size of the mother or to her pre-pregnant plasma volume. Red cell mass normally rises by about 200–250 ml during pregnancy. The increase is greater when additional iron supplements are given. Capacity for oxygen transport is raised by the increased red cell mass, which serves to meet an increased demand for oxygen as the fetus grows and the maternal reproductive organs enlarge.

Plasma concentrations of lipids, fat-soluble vitamins and certain carrier proteins usually increase during pregnancy, whereas there is a fall in concentrations of albumin, most amino acids, many minerals and water-soluble vitamins. This fall may be partly due to increased glomerular filtration which results in increased urinary excretion of some amino acids, several vitamins and minerals. However, lower circulating concentrations of nutrients are not generally indicative of altered nutritional status.

2.3 Metabolic changes and adaptive responses

Changes in maternal hormone secretions lead to changes in the utilisation of carbohydrate, fat and protein during pregnancy. The fetus requires a continual supply of glucose and amino acids for growth, and a hormone produced by the placenta, human chorionic somatomammotropin, is thought to encourage maternal

tissues to make greater use of lipids for energy production, increasing the availability of glucose and amino acids for the fetus.

Changes in hormone levels also help to ensure that maternal lean tissues are conserved, and are not used to provide energy or amino acids for the fetus. The rate of accumulation of nitrogen rises ten-fold over the course of pregnancy, with apparently no rise in nitrogen balance. A 30% reduction in urea synthesis and a fall in plasma urea concentration in the last trimester of pregnancy have been observed. This suggests that maternal breakdown of amino acids may be suppressed, representing a mechanism for protein sparing. Evidence also suggests that protein may be stored in early pregnancy and used at a later stage to meet the demands of the growing fetus.

Adaptive responses help to meet the increased demands for nutrients, irrespective of the nutritional status of the mother. Such homeostatic responses include increased absorption of iron and calcium. Other minerals, such as copper and zinc, may also show improved absorption. There is reduced urinary excretion of some nutrients including riboflavin and the amino acid taurine (Naismith *et al.* 1987).

Increased secretion of the hormone aldosterone, particularly towards the end of pregnancy, may lead to increased reabsorption of sodium from the renal tubules which may encourage fluid retention.

2.4 Key points

- For women with a normal pre-pregnancy weight, an average weight gain of 12 kg (range 10–14 kg) is associated with the lowest risk of complications during pregnancy and labour, and with a reduced likelihood of having a LBW infant.
- In practice, women who are normally of a healthy weight vary widely in the amount of weight they gain during pregnancy.
- There are currently no official recommendations for weight gain in the UK; however, in the USA, there are recommendations based on pre-pregnancy BMI.
- Low gestational weight gain is associated with an increased risk of having a LBW baby. Conversely, excessive weight gain is associated with complications during pregnancy and an increased likelihood of overweight and obesity in the mother after the birth.
- Several metabolic and hormonal changes take place during pregnancy that help to meet the demands of the growing fetus, *e.g.* increased absorption of minerals, such as iron and calcium.

3 Birthweight and the fetal origins hypothesis

3.1 Factors associated with birthweight

The ideal outcome of pregnancy is the delivery of a full-term healthy infant with a birthweight of 3.1–3.6 kg. This birthweight range is associated with optimal maternal outcomes in terms of the prevention of maternal mortality and complications of pregnancy, labour and delivery, and optimal fetal outcomes in terms of preventing pre- and perinatal morbidity and mortality, and allowing for adequate fetal growth and development (WHO 1995).

Macrosomia (birthweight >4.5 kg) is associated with obstetric complications, birth trauma and higher rates of neonatal morbidity and mortality. LBW (birthweight <2.5 kg) is also associated with an increased risk of neonatal morbidity and mortality. LBW is a leading cause of infant mortality; it is associated with deficits in later growth and cognitive development, as well as pulmonary disease, diabetes and heart disease.

In the latest Health Survey for England, the mean reported birthweight was 3.32 kg (Sproston & Primates 2003). No significant difference was found between the birthweights of male (3.34 kg) and female (3.31 kg) newborns. The proportion of LBW infants was 7%, which is in line with the 1998 figure (Macfarlane *et al.* 2000). This percentage has in fact remained constant in the UK over the past two decades, and is marginally higher than the average for Western Europe of 6.7% (UNICEF/WHO 2004).

Studies of firstborn children of mothers and daughters suggest that genetic factors play only a small part in determining birthweight (Carr-Hill *et al.* 1987). The most important factors are the rate of fetal growth and the duration of pregnancy. Infants born prematurely (before 37 weeks of pregnancy) are generally LBW; however, a full-term infant may be born small if it was unable to grow properly in the uterus. Infants from multiple births also tend to be smaller than singleton infants.

Lower socio-economic status is associated with adverse pregnancy outcomes, including LBW and an increased risk of neonatal and post-neonatal mortality. In the UK, there is a marked social gradient in rates of LBW, despite free antenatal care throughout the country. Risk factors for having a LBW baby and potential mediating variables between low socio-economic status and LBW are shown in Table 3. There are also ethnic differences in birthweight; for example, a higher prevalence of LBW has been found in black women in the

Table 3 Risk factors for low birthweight (LBW) and links with low socio-economic status (SES)

Risk factor	Link with low SES
Anthropometry/nutritional status	Short stature, low pre-pregnancy BMI, low gestational weight gain more common in low SES women
Micronutrient intake	Low dietary intake more common in low SES women
Smoking	Higher prevalence and heavier smoking among low SES women
Substance misuse	More common among low SES women
Work/physical activity	Prolonged standing and strenuous work more common among low SES women
Prenatal care	Lower uptake among low SES women
Bacterial vaginosis	More common in low SES women
Multiple birth	Less common among low SES women
Psychosocial factors	More stressful life events, more chronic stressors, more common depression and low levels of social support in low-SES groups

Source: adapted from Bull *et al.* (2003).

BMI, body mass index.

USA and Asian women living in the UK (Kramer *et al.* 2000), although not all ethnic groups living in developed countries exhibit this pattern (Bull *et al.* 2003).

Estimates of trends in birthweight are used to reflect infant health and are an indicator of the future health status of the adult population. In the UK, there has recently been renewed emphasis on reducing health inequalities through the different generations. An important priority has been to reduce the gaps in infant mortality between socio-economic groups. As LBW is a leading cause of infant mortality, reducing the incidence of LBW in the UK is a current focus of public health attention (Bull *et al.* 2003).

3.2 The fetal origins of adult disease hypothesis

The theory that many diseases in adulthood may have their origins *in utero* has provoked much research and debate over recent years. The work of David Barker and colleagues from the Medical Research Council (MRC) Unit in Southampton, whose early work was in the field of cardiovascular disease (CVD), has been central to the development of the 'fetal origins hypothesis'. Since then, Barker and many other research groups have investigated potential links between fetal growth and the development of other diseases in adult life, including hypertension, type 2 diabetes, obesity and cancer.

The fetal origins hypothesis states that impaired intrauterine growth and development may be the root cause of many degenerative diseases of later life. It is postulated that this occurs through the mechanism of 'fetal programming', whereby a stimulus or insult at a critical period in early life development has a permanent effect on the structure, physiology or function of different organs and tissues (Godfrey & Barker 2000).

There is now a substantial body of evidence linking size at birth with the risk of adult disease. Fetal growth restriction, resulting in LBW and low weight gain in infancy, are associated with an increased risk of adult CVD, hypertension, type 2 diabetes and the insulin resistance syndrome (Fall 2005). The fetal origins hypothesis proposes that these associations reflect permanent metabolic and structural changes resulting from undernutrition during critical periods of early development (Fall 2005). However, an alternative explanation is that there is a common underlying genetic basis to both reduced fetal growth and the risk of CVD and other disease factors.

CVD risk is also increased if an individual experiences an early adiposity rebound, or catch-up growth during childhood (crossing centiles for weight and BMI upwards). There is some evidence that small size at birth is associated with abdominal obesity in adulthood and this is exacerbated by early catch-up growth (Fall 2005).

Animal studies have shown that hypertension and insulin resistance can be programmed *in utero* by restricting the mother's diet during pregnancy. However, there is currently insufficient data to determine whether maternal nutritional status and diet influences CVD risk in humans, through the mechanism of fetal programming. The outcomes of a number of ongoing prospective studies in this area are anticipated in the next few years.

Poor maternal diet is a major cause of LBW globally, but its impact in well-nourished populations in developed countries remains unclear. There is currently little evidence that manipulating the diet of already well-nourished individuals can influence fetal growth and subsequent birthweight, and therefore it has not been possible to make specific dietary recommendations with the aim of preventing LBW and adult diseases in later

life. However, achieving a healthy bodyweight prior to pregnancy helps to reduce the risk of having a LBW baby. These issues have been summarised in detail in a recent British Nutrition Foundation (BNF) Task Force report on CVD (see Fall 2005).

3.3 Key points

- A birthweight of 3.1–3.6 kg has been shown to be associated with optimal maternal and fetal outcomes for a full-term infant.
- Macrosomia (birthweight >4.5 kg) is associated with a number of obstetric complications, as well as higher rates of neonatal morbidity and mortality.
- LBW (birthweight <2.5 kg) is associated with an increased risk of neonatal morbidity and mortality, as well as an increased risk of diseases in later life.
- There are a number of risk factors for having a LBW infant, including low pre-pregnancy BMI, poor diet, smoking and use of alcohol or drugs during pregnancy, and many of these factors are associated with low socioeconomic status.
- LBW is associated with increased rates of CVD, hypertension and type 2 diabetes in adulthood. The fetal origins hypothesis states that these effects may be a consequence of ‘fetal programming’, whereby a stimulus or insult at a critical, sensitive period in development has a permanent effect on physiology, structure or metabolism of tissues and organs.
- However, there is little evidence that in healthy, well-nourished women, the maternal diet can be manipulated in order to prevent LBW and the risk of subsequent diseases in later life of the offspring.

4 Essential fatty acids and pregnancy

The essential fatty acids (EFAs) linoleic (18:2 *n*-6) and alpha-linolenic acid (18:3 *n*-3), and their long-chain derivatives, arachidonic acid (AA) and docosahexaenoic

acid (DHA), are important structural components of cell membranes and therefore essential to the formation of new tissues (see Fig. 1). Dietary intake is therefore vital during pregnancy for the development of the fetus. The long-chain polyunsaturated fatty acids (PUFAs) are particularly important for neural development and growth, so an adequate supply to the fetus is essential during pregnancy (BNF 1999). Whether there may be any benefit to women taking supplements, containing long-chain PUFAs, *e.g.* fish oil supplements during pregnancy, is another question and has been the subject of much debate and recent research, which is outlined in this section.

The long-chain *n*-3 fatty acid, DHA, can be synthesised from alpha-linolenic acid to a limited and probably variable extent, but the best dietary source is oil-rich fish, in which it is available pre-formed. In contrast, it is thought that sufficient AA can be synthesised from linoleic acid (see Table 4 for dietary sources of EFAs). DHA is essential for the development of the brain and retina of the fetus. DHA is found in very high concentrations in the photoreceptor cells of the retina,

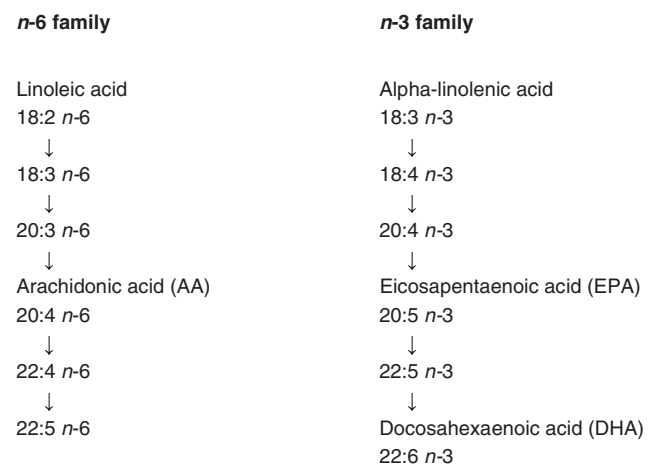


Figure 1 The *n*-6 and *n*-3 polyunsaturated fatty acid pathways.

Table 4 Dietary sources of essential fatty acids

	Rich sources	Moderate sources
<i>n</i> -6 PUFAs	Linoleic acid Vegetable oils, <i>e.g.</i> sunflower, corn and soybean oils, and spreads made from these.	Peanut and rapeseed oils.
<i>n</i> -3 PUFAs	Alpha-linolenic acid Rapeseed, walnut, soya and blended vegetable oils, and walnuts.	Meat from grass-fed ruminants, vegetables and meat/eggs from animals fed on a diet enriched in alpha-linolenic acid.
	EPA and DHA Oil-rich fish, <i>e.g.</i> salmon, trout, mackerel, sardines and fresh tuna.	Foods enriched or fortified with EPA/DHA.

DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; PUFAs, polyunsaturated fatty acids.

and is the most common fatty acid in brain cellular membranes. DHA and AA together make up more than 30% of the phospholipid content of the brain and retina (BNF 1999).

The brain grows most rapidly during the third trimester of pregnancy and in early infancy and consequently, the concentration of DHA in the brain and retina of the fetus increases steadily during the last trimester. An adequate dietary supply of long-chain PUFAs is therefore thought to be important during this time to support normal growth, neurological development and cognitive function (Uauy *et al.* 1996).

Dietary intake of EFAs during pregnancy must be sufficient to meet the mother's requirements as well as those of the developing fetus. There is evidence, however, that maternal body stores of these fatty acids can be mobilised if dietary intake is low. Linoleic acid (*n*-6) is stored in adipose tissue in high amounts; however, the amount of alpha-linolenic acid (*n*-3) present in stores is lower. The fatty acid status of an infant has been found to be highly correlated with that of its mother. During the course of pregnancy, the concentration of EFAs in maternal blood falls by approximately 40%. Levels of AA (*n*-6) fall by around 23% and of DHA (*n*-3) fall by an average of 52% by the time of birth. At the same time, the levels of non-essential fatty acids rise, and normalisation of these levels after delivery is slow (Al *et al.* 1995).

The DHA status of infants from multiple-births has been found to be lower than that of singleton infants, and newborn infants from second and third pregnancies have been found to have a lower DHA status than first-born infants. Pre-term infants also have lower levels of DHA compared with full-term neonates. This indicates that under certain circumstances, such as multiple pregnancies, the demands on the mother to supply long-chain PUFAs to the fetus are particularly high, and therefore supplementation may be an important consideration (Al *et al.* 2000).

Evidence has been gathering that supplementation with long-chain *n*-3 PUFAs, *e.g.* from fish oils, during pregnancy may help to prevent premature delivery and LBW. The results of several randomised clinical studies have indicated that supplementation with fish oils containing DHA and eicosapentaenoic acid (EPA) may lead to modest increases in gestation length, birthweight or both (Makrides & Gibson 2000). A review by Allen and Harris (2001) concludes that there is evidence from both animal and human studies that the ratio of *n*-3 to *n*-6 fatty acid intake may influence gestation length and *n*-3 fatty acid intake may be inadequate. The mechanism for this may be by influencing the balance of prostaglandins

involved in the process of parturition or by improving placental blood flow which may lead to improved fetal growth. Supplementation with long-chain *n*-3 PUFAs, *e.g.* DHA, may be particularly useful for preventing pre-term delivery in high-risk pregnancies (Allen & Harris 2001).

Several other recent studies have found an association between long-chain *n*-3 PUFA intake and increased gestational length. Olsen and Secher (2002) carried out a prospective cohort study on pregnant women in Denmark and found that a low intake of fish was a risk factor for both premature delivery and LBW. A randomised controlled trial carried out on a group of pregnant women living in Kansas City (USA) found that a higher intake of DHA (133 mg/day, compared with 33 mg/day) in the last trimester of pregnancy was associated with a significant increase in gestation length (Smuts *et al.* 2003).

However, the most recent study carried out in this area has found conflicting results. Oken and colleagues examined data from a cohort of over 2000 pregnant women from the Massachusetts area for associations between marine long-chain *n*-3 PUFA and seafood intake and length of gestation, birthweight and birthweight-for-gestational-age (as a marker for fetal growth). Seafood and long-chain *n*-3 PUFA intakes were not found to be associated with gestation length or the risk of pre-term birth. However, seafood and marine *n*-3 PUFA intakes were found to be associated with moderately lower birthweight and reduced fetal growth. The authors conclude that previous studies that have shown an association between long-chain *n*-3 PUFA intake and increased birthweight have not adjusted for gestational age, so have been unable to determine whether long-chain *n*-3 PUFA intake influences fetal growth. The authors acknowledge that there may be other explanations; for example, gestational length may be adversely affected if *n*-3 PUFA intake is below a certain level (Oken *et al.* 2004). Further research is therefore required in order to determine how these types of fatty acids influence birth outcome.

A report published by the UK Health Development Agency (HDA) has examined the evidence from review papers regarding the effect of fish oil supplementation on birthweight and the risk of pre-term birth (Bull *et al.* 2003). The report concluded that the evidence with regard to the use of fish oil supplements to prevent LBW was conflicting. In addition, the Department of Health (DH) advises that women should not consume fish oil supplements (*e.g.* cod liver oil) during pregnancy due to their potentially high vitamin A content (see section 7.1).

4.1 Key points

- The long-chain PUFAs, AA and DHA are important for fetal development of the brain, nervous system and retina, so an adequate supply is essential during pregnancy.
- There is currently a lot of research interest in fish oil supplements and their potential benefits during pregnancy. There is some evidence that increasing the intake of long-chain *n*-3 PUFAs during pregnancy (*e.g.* from fish oils) may have beneficial effects on birthweight and the duration of pregnancy; however, not all studies have produced consistent results.
- The best dietary source of long-chain *n*-3 PUFAs is oil-rich fish, and regular consumption of oil-rich fish is recommended during pregnancy (up to two portions per week). However, taking cod liver oil supplements is not advised during pregnancy as they can contain high levels of vitamin A (see section 7.1).

5 Pre-pregnancy nutritional issues

5.1 Bodyweight and fertility

It has now been established that fertility in women is affected by their percentage body fat, rather than absolute bodyweight. The average body fat content in women is 28% of bodyweight, and research has shown that a body fat content of at least 22% is necessary for normal ovulatory function and menstruation (Thomas 2001). Women who maintain a low bodyweight, who have suffered from eating disorders, or who diet regularly, often have irregular menstrual cycles and therefore may take longer to conceive (Goldberg 2002). Gaining weight restores fertility, indicating that the relatively high percentage of body fat in females, compared with males, may influence reproduction directly.

However, excessive stores of body fat can also impair fertility. A prospective study of healthy women presenting for treatment using artificial insemination found a lower rate of pregnancy among obese women (BMI > 30) than lean women (BMI < 20). Women with a BMI of 20–25 had the highest rate of pregnancy (Zaadstra *et al.* 1993). The study also showed that body fat distribution may be related to fertility. Women with abdominal fat distribution (waist to hip ratio 0.8 and above) were less likely to conceive than women with peripheral fat distribution (waist to hip ratio less than 0.8). The deposition of excess fat in central depots had more impact on reduced fertility than age or severity of obesity. This could be due to insulin resistance, which is associated with abdominal fat distribution, and its effect

on androgenic hormones and luteinising hormone, which might reduce the viability of the egg.

In a prospective study carried out by Clark *et al.* (1998), a group of overweight, anovulatory women in Australia undertook a weekly programme aimed at lifestyle changes in relation to diet and physical activity, lasting 6 months. Those who completed the programme lost an average of 10.2 kg. This was shown to lead to restored ovulation, conception and a successful pregnancy in the majority of cases.

5.2 Pre-pregnancy weight and birth outcome

It is recommended that women who are planning a pregnancy should attempt to reach a healthy bodyweight (BMI of 20–25) before they become pregnant, as being overweight or obese, or underweight prior to conception is associated with an increased risk of a number of complications (see Goldberg 2002).

Mothers with a low BMI prior to and during pregnancy are at an increased risk of having a LBW infant (see also section 2.1). Being underweight is also associated with an increased risk of morbidity and mortality in the newborn infant (IOM 1990) and an increased risk of degenerative diseases in later life of the offspring (see section 3).

Being overweight or obese prior to and during pregnancy is associated with an increased risk of several complications, including gestational diabetes, pregnancy-induced hypertension, pre-eclampsia and congenital defects. Obesity is also linked to a greater risk of abnormal labour and an increased likelihood of needing an emergency caesarean operation. Infants born pre-term to a mother who is obese, are also less likely to survive (Goldberg 2002). Moreover, the incidence of these complications appears to increase as the pre-pregnancy BMI increases, so women who are severely obese are at the greatest risk of experiencing such complications (Galtier-Dereure *et al.* 1995).

As the prevalence of overweight and obesity in the UK is on the increase, such complications are a major cause of concern. Currently, 44% of women aged 25–34 in the UK are classified as overweight or obese (BMI > 25) (Henderson *et al.* 2003a). Dieting to lose weight is not advisable during pregnancy; therefore, it is important that women who are overweight or obese should attempt to reach a healthy bodyweight (*i.e.* a BMI of 20–25) before trying to conceive.

5.3 Nutritional status

It is now well established that maternal nutritional status at the time of conception is an important determi-

nant of embryonic and fetal growth. The embryo is most vulnerable to the effects of poor maternal diet during the first few weeks of development, often before pregnancy has been confirmed. Cell differentiation is most rapid at this time and any abnormalities in cell division cannot be corrected at a later stage. Most organs, although very small, have already been formed 3–7 weeks after the last menstrual period and any teratogenic effects (including abnormal development) may have occurred by this time.

Improving nutritional status in women prior to pregnancy has a beneficial influence on subsequent birth outcomes (Caan *et al.* 1987). If all women of childbearing age were to eat a varied and adequate diet, this would help to correct any nutritional imbalances and would help to ensure that the fetus has the best nutritional environment in which to develop. Attention to the diet at this stage also sets appropriate dietary habits to be followed throughout pregnancy.

The Food Standards Agency (FSA) provides dietary advice for women planning a pregnancy (see FSA 2005a). The general dietary recommendations are similar to the advice given to non-pregnant women in terms of following a healthy, varied and balanced diet to ensure an adequate intake of energy and nutrients. There is also an additional emphasis on consuming plenty of iron- and folate-rich foods. Women who may become pregnant are also advised to take a folic acid supplement of 400 µg per day (see section 5.4).

It is also recommended that women who are planning to have a baby should try to limit their alcohol and caffeine intakes and avoid taking vitamin A supplements, or foods containing high levels of vitamin A (such as liver and liver products). Fish, including oil-rich fish, should be included in the diet; however, certain types of fish (shark, swordfish and marlin) should be avoided, and tuna intake should be limited, because of possible contamination. See section 7 for background and further information on food safety issues both prior to and during pregnancy.

5.4 Folate/folic acid

It is now well recognised that folic acid (the synthetic form of the vitamin folate) is of critical importance both pre- and peri-conceptionally in protecting against neural tube defects (NTDs) in the developing fetus. The neural tube develops into the spine and NTDs occur when the brain and skull and/or the spinal cord and its protective spinal column do not develop properly within the first 4 weeks after conception. The most common NTDs are anencephaly, which results in stillbirth or death soon after delivery, and spina bifida, which may lead to a

wide range of physical disabilities, including partial or total paralysis.

There are variations in the prevalence of NTDs, which depend on demographic, ethnic and social factors, and environmental factors also seem to influence the risk. In 1998, 93 children were recorded as being born with NTDs in the UK. The incidence of affected pregnancies is difficult to determine. However, it was estimated that in 2002, there were at least 551–631 NTD-affected pregnancies in the UK and the incidence changed little over the 1990s (SACN 2005).

Differences in mean serum folate levels between NTD-affected pregnancies and unaffected pregnancies were first reported by the Leeds Pregnancy Nutrition Study in 1976, leading researchers to conclude that folate deficiency may be significant in the causation of NTDs (Smithells *et al.* 1976). Subsequent intervention studies in women who had previously given birth to an infant with a NTD, found that folic acid supplementation in the peri-conceptional period significantly reduced the incidence of further NTD-affected pregnancies (*e.g.* Smithells *et al.* 1980).

There is now conclusive evidence from a number of randomised controlled trials that folic acid supplementation can prevent NTDs (DH 2000). The definitive study was a randomised double-blind prevention trial carried out by the MRC in multiple centres across seven countries, which established that folic acid supplementation (4 mg/day) before conception had a 72% protective effect on the incidence of NTDs in pregnancy (MRC Vitamin Study Research Group 1991).

Furthermore, a recent study by Wald (2004) indicates that there is an inverse dose–response relationship between folate status and the risk of NTDs. This research emphasises the critical importance of folic acid supplementation before the time of conception, as once pregnancy is established, it is probably too late for folic acid to have a protective effect (Buttriss 2004). Wald has estimated that supplementation with 400 µg (0.4 mg) of folic acid per day results in a reduction in the incidence of NTDs of 36%. Supplementation with 4 mg per day is estimated to prevent 80% of NTDs (Wald 2004).

The mechanism by which folate supplementation may help to prevent NTDs has not been clearly established. A recent study carried out in the USA has shown that women with a current or previous pregnancy affected by NTDs are more likely to have serum-containing autoantibodies against folate receptors. These autoantibodies can bind to folate receptors and block the cellular uptake of folate. Further research is required to determine whether this observed association is causal to the development of NTDs (Rothenberg *et al.* 2004).

Table 5 The folate/folic acid content of a range of foods (per 100 g and per portion)

Food	Amount (μg) per 100 g	Amount (μg) per portion
Cereals & cereal products		
Yeast extract	2620	26 (portion thinly spread on bread)
Fortified breakfast cereals	111–333	33–100 (30 g portion)
Granary bread	88	32 (medium slice)
Fruit		
Raspberries, raw	33	20 (60 g)
Oranges	31	50 (medium orange)
Orange juice	18	29 (160 ml glass)
Vegetables		
Asparagus, boiled	173	216 (5 spears)
Spring greens, boiled	66	63 (95 g portion)
Broccoli, boiled	64	54 (85 g portion)
Peas, frozen, boiled	47	33 (70 g portion)
Lentils, red, dried, boiled	33	13 (1 tablespoon)
Other foods		
Beef mince, cooked	17	24 (140 g portion)
Milk, semi-skimmed	9	23 (250 ml glass)
Peanuts	110	14 (10 nuts)

Source: McCance and Widdowson's *The Composition of Foods* (FSA 2002a).

The Department of Health (DH) currently recommends that all women of childbearing age who may become pregnant should take a supplement of 400 μg of folic acid per day until the 12th week of pregnancy and try to consume foods which are naturally rich in folate (e.g. green vegetables, oranges), as well as foods fortified with folic acid, such as some breads and breakfast cereals. Women who realise they are pregnant and have not been taking folic acid should start taking it immediately and continue until the 12th week of pregnancy. Additionally, women who have a family history of NTDs and who may become pregnant, may be advised by their doctor to take a larger supplement of 5 mg (5000 μg) per day, again until the 12th week of pregnancy (DH 1992; 2000).

This emphasis on supplementation is due to the fact that the extra folate required peri-conceptionally is difficult for women to obtain through the diet alone. Folic acid (the synthetic form) is also more bioavailable than the natural folates found in food, hence foods fortified with folic acid are also an important source of the vitamin. Table 5 gives some examples of the folate content of a range of foods. Important sources include yeast extract, green leafy vegetables, oranges, pulses and fortified bread and breakfast cereals. Liver is a rich source, but consumption of liver and liver products is not recommended during pregnancy (see section 7.1).

Although there have been several government campaigns to increase awareness of the importance of folic acid supplementation, many pregnancies are still unplanned and in these cases, women often do not start taking folic acid supplements until it is too late (McGovern *et al.* 1997). It is estimated that in some parts of the UK, up to half of all pregnancies are unplanned and for this reason, the statutory fortification of flour with folic acid has been debated in the UK.

In a report from the Committee on Medical Aspects of Food Policy (COMA), it was estimated that fortification of flour at a level of 240 μg per 100 g would reduce the current level of NTDs by 41%, without leading to unacceptably high intakes in other groups of the population (DH 2000). However, in 2002 the Board of the FSA decided not to proceed with fortification, primarily due to concerns about the possibility of masking vitamin B₁₂ deficiency anaemia in the elderly population.

The government's Scientific Advisory Committee on Nutrition (SACN) was subsequently asked to reconsider the issue, and has recently published a draft report on folate and disease prevention (SACN 2005). There is now evidence from countries that have introduced fortification policies, such as the USA and Canada, that fortification of flour can reduce the incidence of NTDs by around 27–50%. The report reaffirms the conclusion from the earlier COMA report, that there is a need, on

Table 6 Extra energy and nutrient requirements during pregnancy

	Non-pregnant women (19–50 years)	Extra requirement for pregnancy	Comments
Energy (kcal)	1940	+200	Last trimester
Protein (g)	45	+6	
Thiamin (B ₁) (mg)	0.8	+0.1	Last trimester
Riboflavin (B ₂) (mg)	1.1	+0.3	
Folate* (µg)	200	+100	
Vitamin C (mg)	40	+10	Last trimester
Vitamin A (µg)	600	+100	
Vitamin D (µg)	No RNI	10	

Source: DH (1991).

*Pregnant women are also advised to take a 400 µg/day supplement of folic acid prior to and until the 12th week of pregnancy (more if there is a history of NTDs). NTDs, neural tube defects; RNI, Reference Nutrient Intake.

balance, for the introduction of mandatory fortification of flour with folic acid in the UK (SACN 2005).

5.5 Key points

- It is recommended that women who are considering a pregnancy should try to achieve a healthy bodyweight (BMI of 20–25), as being either underweight or overweight can affect both fertility and birth outcome.
- Pre-pregnancy nutritional status is an important determinant of fetal growth and development, and therefore a healthy and varied diet is important for women planning a pregnancy. Certain food safety recommendations should also be followed (see section 7).
- It is now well established that taking a folic acid supplement prior to conception and during the first 12 weeks of pregnancy helps prevent the occurrence of NTDs, such as spina bifida.

6 Nutritional requirements during pregnancy

It is now recognised that pregnant women do not actually have to 'eat for two'; however, a healthy and varied diet, which is rich in nutrients, is important for both the mother and the baby. The developing fetus obtains all of its nutrients through the placenta, so dietary intake has to meet the needs of the mother as well as the products of conception, and enable the mother to lay down stores of nutrients required for the development of the fetus and lactation after the birth.

The healthy eating guidelines for pregnant women are actually very similar to those for non-pregnant women, with a few exceptions. The main recommendation is to eat a healthy, balanced diet based on the *Balance of Good Health* model, which includes plenty of starchy

carbohydrates, such as bread, rice, pasta and potatoes, and is rich in fruit and vegetables. A healthy diet includes moderate amounts of dairy foods and protein-containing foods, *e.g.* lean meat, fish, eggs and pulses (beans and lentils), and limited amounts of foods high in fat or sugar.

Changes in metabolism, leading to more efficient utilisation and absorption of nutrients occur during pregnancy, which means that for many nutrients, such as calcium, an increase in dietary intake over and above that which is normally required, is not necessary. For some nutrients, however, an increase in intake is recommended. The UK COMA panel has set specific Reference Nutrient Intakes (RNIs)¹ for pregnancy. Table 6 shows the nutrients for which an increase in requirement has been established.

So far, there have been very few dietary surveys that have focused on nutrient intakes in pregnant women in the UK. However, the Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) collected data on the diets of almost 12 000 women at 32 weeks of gestation using a food frequency questionnaire (FFQ). The data suggested that nutrient intakes in UK pregnant women are sufficient, with the exceptions of iron, magnesium and folate (Rogers & Emmett 1998).

The recent National Diet and Nutrition Survey (NDNS) of adults aged 19–64 years indicates that a proportion of women of childbearing age have low intakes of several vitamins and minerals, in particular vitamin A, riboflavin, iron, calcium, magnesium, potassium and iodine (Henderson *et al.* 2003b). Table 7 shows the per-

¹The Reference Nutrient Intake (RNI) for protein or a vitamin or mineral is the amount of nutrient that is enough, or more than enough, for about 97.5% of people in a group.

Table 7 Percentages of women with mean daily nutrient intakes (from all sources) below the LRNI², for selected nutrients

Nutrient	19–24 years (%)	25–34 years (%)	35–49 years (%)
Vitamin A	15	10	6
Riboflavin (B ₂)	13	10	5
Vitamin B ₆	5	1	2
Folate	3	2	1
Total iron	40	40	25
Calcium	8	6	6
Magnesium	22	20	10
Potassium	30	30	16
Zinc	5	5	3
Iodine	12	5	4

Source: National Diet and Nutrition Survey of adults aged 19–64 years (Henderson *et al.* 2003b).

centage of women with intake from all sources (food and supplements) below the Lower Reference Nutrient Intake (LRNI),² for selected nutrients.

These data indicate that many women of childbearing age are not meeting their nutrient requirements, and this clearly has implications for pregnancy. However, low intakes of some nutrients may be partly attributable to low energy intakes, or to underreporting which is a common problem in dietary surveys. The nutrients of particular concern are those for which there is an increased requirement during pregnancy (vitamin A, riboflavin and folate), as well as iron, and these are discussed in more detail later in this section.

Much of the following discussion is based on the recommendations of the report of the Panel on Dietary Reference Values (DRVs) of the Committee on Medical Aspects of Food Policy (DH 1991).

6.1 Energy

The maternal diet during pregnancy must provide sufficient energy to ensure the delivery of a full-term, healthy infant of adequate size and appropriate body composition. Ideally, a woman should enter pregnancy with a healthy weight and good nutritional status. The additional energy requirements of pregnancy therefore result from the following (Goldberg 2002):

- the need to deposit energy in the form of new tissue; this includes the fetus, placenta and amniotic fluid;

²The Lower Reference Nutrient Intake (LRNI) for protein or a vitamin or mineral is the amount of nutrient that is enough for only the few people in a group (2.5%) who have low needs. The majority of individuals need more.

- the growth of existing maternal tissues, including breast and uterus;
- extra maternal fat deposition;
- increased energy requirements for tissue synthesis;
- increased oxygen consumption by maternal organs;
- the energy needs of the products of conception (fetus and placenta), particularly in the later stages of pregnancy.

Some of the energy costs of pregnancy are thought to be met by a reduction in energy expenditure, as women are assumed to become more sedentary during pregnancy. However, this is not the case for all individuals. Some women may even become more active during pregnancy, for example if they go on maternity leave from a sedentary job. In addition, general physical activity requires more energy during pregnancy due to an overall increase in body mass, *i.e.* women tend to expend more energy carrying out the same activities. Even within a particular society, there is a wide variation in weight gain and energy expenditure during pregnancy, and therefore in energy requirements.

A joint FAO/WHO/UNU Expert Consultation on Human Energy Requirements was held in 2001, and the recently published report reviews the recommendations of the preceding consultation (held in 1981). The total energy cost of pregnancy has now been estimated at around 321 MJ (77 000 kcal). This is based on data from longitudinal studies and factorial calculations of the extra energy required during this period (FAO/WHO/UNU 2004).

The consultation reviewed data from a number of longitudinal studies carried out in healthy, well-nourished groups of women with favourable pregnancy outcomes, in order to calculate the extra energy required during pregnancy. This was calculated, based on a mean gestational weight gain of 12 kg, with two factorial approaches, using either the cumulative increment in basal metabolic rate (BMR) or the cumulative increment in total energy expenditure (TEE) during pregnancy, in addition to the energy deposited as protein and fat.

It has previously been suggested that the energy requirements of pregnant women should, as with other adult groups, be based on multiples of BMR, to take into account physical activity levels, as women do not necessarily reduce their energy expenditure during pregnancy (Prentice *et al.* 1996). Several studies have measured BMR at different stages of pregnancy. From these studies, an average increase in BMR of 154 MJ throughout the gestational period was determined. For each trimester, the average increases in BMR were around 5%,

10% and 25% of pre-pregnancy BMR respectively; however, there is a wide range in individual variability.

Longitudinal studies using doubly labelled water techniques in developed countries, such as the UK, Sweden and the USA, have found an average increase in TEE of 16.5% by the third trimester of pregnancy. TEE was shown to increase by around 1%, 6% and 17% during the first, second and third trimesters respectively, which is proportional to the increments in weight gain during each trimester. For an average weight gain of 12 kg, the increase in energy required would be 0.085, 0.35 and 1.3 MJ/day (20, 85 and 310 kcal/day) for each trimester (Butte & King 2002).

Table 8 shows the additional energy costs of pregnancy in each trimester, based on calculations using increments in TEE, for women with an average gestational weight gain of 12 kg. The estimates made using calculations based on increases in BMR were, in fact, very similar. By averaging the two types of factorial calculations, the current estimate of 321 MJ (77 000 kcal) was calculated as the extra energy cost of pregnancy (FAO/WHO/UNU 2004).

As Table 8 indicates, the additional energy requirements are not distributed evenly throughout the duration of pregnancy. Again, by averaging the two different factorial calculations, the additional energy costs come to 0.35, 1.2 and 2.0 MJ/day (85, 285 and 475 kcal/day) respectively, for each trimester. The joint consultation recommends that in order to achieve this extra energy intake, practical advice would be to add the small requirement for the first trimester to the second trimester. This would therefore mean that an extra 1.5 MJ/day (360 kcal/day) would be required during the second and 2.0 MJ/day (475 kcal/day) required during the final trimester (FAO/WHO/UNU 2004).

These values are based on average energy requirements calculated from studies of healthy, well-nourished groups of women. However, the energy requirements of individual women during pregnancy vary widely and are influenced by many factors, so it can be difficult to make individual recommendations.

In the UK, the current recommendations are somewhat more conservative. The DRV for energy intake during pregnancy is an extra 200 kcal/day during the third trimester only. Women who are underweight at the start of their pregnancy and women who do not reduce their activity may require more than this amount (DH 1991). However, it is currently assumed that if maternal weight gain and fetal growth are adequate, then maternal energy intake must be sufficient to meet individual requirements (Goldberg 2002).

6.2 Protein

The total protein requirement during pregnancy has been estimated to be approximately 925 g for a woman gaining 12.5 kg and delivering an infant of 3.3 kg (Hytten 1980). Protein is not gained at a constant rate, the rate at which protein is deposited increases as pregnancy progresses. Estimates for the first, second, third and fourth quarters are 0.64, 1.84, 4.76 and 6.10 g of protein per day, respectively (FAO/WHO/UNU 1985). However, more recent estimates from longitudinal studies of women in developed countries (*e.g.* UK, USA) suggest protein gains in pregnancy may be lower, in the range of 497 to 696 g for an average weight gain of 12 kg (FAO/WHO/UNU 2004).

The joint FAO/WHO/UNU consultation determined that an average increase in protein intake of 6 g per day was required during pregnancy. This was based on the calculated average gain of 925 g of protein, plus 30% (2 standard deviations of birthweight), to allow for the protein gains of nearly all normal pregnant women. The figures also had to be adjusted for the efficiency with which dietary protein is converted to fetal, placental and maternal tissues (FAO/WHO/UNU 1985). A new FAO consultation on protein requirements is due to report in 2006.

In the UK, the DRV for protein intake is in line with the above recommendation, at an extra 6 g of protein per day throughout pregnancy, to achieve a total intake of 51 g per day. This is based on calculations of the

Table 8 Energy cost of pregnancy estimated from increments in total energy expenditure and energy deposition

	1st trimester (kJ/day)	2nd trimester (kJ/day)	3rd trimester (kJ/day)	Total energy cost	
				(MJ)	(kcal)
Protein deposition	0	30	121	14.1	3 370
Fat deposition	202	732	654	144.8	34 600
Total energy expenditure	85	350	1300	161.4	38 560
Total energy cost	287	1112	2075	320.2	76 530

Source: FAO/WHO/UNU (2004).

additional protein required for the products of conception and growth of maternal tissues, assuming a birthweight of 3.3 kg (DH 1991). The majority of women in the UK consume more protein than this, however, so it is unlikely that most women need to increase their protein intake. According to the recent NDNS of adults, average protein intake is 60 g per day in women aged 19–24 years and 59 g per day in women aged 25–34 years (Henderson *et al.* 2003c).

6.3 Fat

The DRV panel did not give any specific values for additional fat requirements during pregnancy (DH 1991). However, pregnant women and those planning a pregnancy need an adequate dietary intake of essential fatty acids and their longer-chain derivatives, DHA and AA, which are necessary for the development of the brain and nervous system of the fetus, particularly in late pregnancy (BNF 1999). The best dietary source of long-chain *n*-3 fatty acids (EPA and DHA) is oil-rich fish. There is also some evidence that an increased intake of long-chain *n*-3 fatty acids during pregnancy may have beneficial effects on birthweight or the duration of pregnancy (*e.g.* Allen & Harris 2001). See section 4 for a more detailed discussion on essential fatty acid requirements during pregnancy.

6.4 Carbohydrate

Requirements for starch, sugar and non-starch polysaccharides (dietary fibre) during pregnancy are not increased. However, constipation, which may be partly attributed to reduced motility of the gastrointestinal tract, is common at all stages of pregnancy. Women with low intakes of non-starch polysaccharides may benefit from increased intakes, to within a range of 12–24 g per day, along with increased fluid intakes to encourage regular bowel movement (see section 8.2).

6.5 Vitamins

The DRV panel established DRVs for nine vitamins, with increments during pregnancy for vitamins A, C and D, thiamin, riboflavin and folate. These are discussed below.

6.5.1 Vitamin A

Extra vitamin A is required during pregnancy for growth and maintenance of the fetus, for fetal stores of vitamin A and for maternal tissue growth. Requirements are highest during the third trimester, when fetal growth is most rapid. The DRV panel concluded that vitamin A

intakes should be increased throughout pregnancy by 100 µg per day (to 700 µg per day). This is to allow for adequate maternal storage so that vitamin A is available to the fetus during late pregnancy.

The recent NDNS of adults indicates that some women, particularly those in the younger age groups, have an intake of vitamin A below the LRNI (see Table 7) (Henderson *et al.* 2003b). However, if taken in excessive amounts, retinol is teratogenic, and therefore pregnant women are advised to avoid liver and liver products and supplements containing retinol [unless advised otherwise by a general practitioner (GP)]. Other dietary sources of vitamin A and beta-carotene (*e.g.* dairy products, eggs, carrots and leafy vegetables) can be included as part of a healthy, balanced diet during pregnancy. See section 7.1 for further details on food safety issues relating to vitamin A.

6.5.2 Thiamin, riboflavin and folate

Thiamin (B₁) and riboflavin (B₂) are needed for the release of energy in the body's cells. Requirements for thiamin parallel the requirements for energy and are subsequently higher for the last trimester of pregnancy (an increase of 0.1 mg to a total of 0.9 mg per day during the last trimester). The increment for average riboflavin intake is 0.3 mg per day (to a total of 1.4 mg per day) throughout pregnancy. Note that an adaptive response to pregnancy is reduced urinary excretion of some nutrients, including riboflavin, helping to meet the increased demand.

The latest NDNS of adults indicates that a significant proportion of women of childbearing age have intakes of riboflavin below the LRNI (see Table 7). Pregnant women should therefore be encouraged to consume plenty of riboflavin-containing foods. The main sources of riboflavin in the UK diet are milk and milk products, cereals and cereal products (mainly fortified breakfast cereals), and meat and meat products (Henderson *et al.* 2003b). Good sources of riboflavin include milk and dairy products, meat, green leafy vegetables, fortified breakfast cereals, yeast extract and liver; however, liver and liver products should be avoided during pregnancy (see section 7.1).

In addition to the recommendation to take a folic acid supplement prior to conception and in the early stages of pregnancy, extra folate is also needed throughout pregnancy in order to prevent megaloblastic anaemia. An increment of 100 µg per day (to a total of 300 µg per day) was set by the DRV panel for the duration of pregnancy. This level of intake can be attained with a well-balanced diet, which includes plenty of folate-rich foods

and foods fortified with folic acid (see Table 5); therefore folic acid supplements are only recommended up to the 12th week of pregnancy (see also section 5.4).

6.5.3 Vitamin C

The increment in vitamin C intake of 10 mg per day (to a total of 50 mg per day) during the last trimester of pregnancy is to ensure that maternal stores are maintained, particularly towards the final stages of pregnancy. The rapidly growing fetus places a moderate extra drain on tissue stores, as it is able to concentrate the vitamin at the expense of circulating vitamin levels and maternal stores.

Vitamin C also has an important role in enhancing the absorption of non-haem sources of iron. Pregnant women are therefore encouraged to consume foods or drinks containing vitamin C, together with iron-rich meals, in order to help with iron absorption (FSA 2005b).

6.5.4 Vitamin D

The vitamin D status of adult women is maintained more by exposure to sunlight than through diet, and there is currently no RNI for vitamin D for adults under 65 years. Some vitamin D is available naturally in foods, including eggs, meat and oil-rich fish. Margarine is fortified with vitamin D by law and it is also added to most fat spreads and some breakfast cereals.

Vitamin D is important for the absorption and utilisation of calcium, needed for the calcification of the fetal skeleton, particularly during the later stages of pregnancy, and low vitamin D status can be detrimental to both the mother and the fetus. A recent study found poor maternal vitamin D status to be associated with reduced bone mass in the offspring (at age 9) and may also increase the risk of osteoporosis in later life (see Javaid *et al.* 2006). Pregnant women therefore need a good supply of vitamin D and supplements of 10 µg per day are currently recommended for all pregnant women (FSA 2005b).

A high prevalence of vitamin D deficiency has been reported among Asian pregnant women in the UK, particularly among those who are vegetarian (Iqbal *et al.* 1994). It is thought that the rate of vitamin D synthesis in the skin may be slower in Asians than in caucasians, increasing the need for dietary and supplemental vitamin D. Women who receive little sunlight exposure, such as those that cover up their skin when outdoors, are also likely to have low vitamin D status, so it is particularly important that they receive supplementary vitamin D during pregnancy.

6.6 Minerals

The DRV panel established DRVs for 10 minerals (DH 1991); however, no increments were established for pregnancy as requirements are not considered to increase. This is mainly because of the more efficient absorption and utilisation of nutrients that occurs during pregnancy.

6.6.1 Calcium

The RNI for calcium for all adults is 700 mg per day and the DRV panel did not consider that any increment was necessary during pregnancy. Babies born at full-term contain approximately 20–30 g of calcium, most of which is laid down during the last trimester. Although calcium demands on the mother are high, particularly during the latter stages of pregnancy, physiological adaptations take place to enable more efficient uptake and utilisation of calcium, so an increased intake from the diet is not usually necessary. These adaptations include:

- An increase in the concentration of maternal free 1,25-dihydroxyvitamin D₃ (synthesised by the placenta) resulting in more efficient calcium absorption.
- Increased absorption may be stimulated by the hormones oestrogen, lactogen and prolactin.
- Enhanced calcium retention, due to an increase in reabsorption in the kidney tubules.
- There is evidence that maternal bone density diminishes during the first 3 months of pregnancy to provide an internal calcium reservoir, which is replenished by the later stages of pregnancy.

The DRV panel did, however, caution that higher maternal calcium intakes would be advisable in adolescent pregnancies. Demineralisation of maternal bone may be detrimental in adolescence, when the skeleton is still increasing in density. Furthermore, any rapid maternal growth spurt may further deplete existing calcium stores. Also, if calcium intakes were low during childhood and early adolescence, calcium stores may be insufficient to optimally meet both maternal and fetal needs. The RNI for calcium for girls aged 15–18 years is greater than that of adults, at 800 mg per day (see also section 9.2).

Other groups that may have inadequate calcium intakes include:

- women who consume little or no milk or dairy products;
- vegan women;

- Asian women who may have a low vitamin D status (see previous section) and also consume a high-fibre diet which can inhibit the absorption of calcium.

Such individuals would benefit from appropriate dietary advice to ensure that they obtain enough calcium throughout pregnancy. Good dietary sources of calcium include milk and dairy products, green leafy vegetables, fish containing soft bones (*e.g.* canned pilchards and sardines), pulses and foods made with fortified flour (*e.g.* bread). Milk and dairy products are the best dietary sources of calcium as they have a high calcium content and the bioavailability is also high. Alternative dietary sources for vegans and women who do not consume dairy foods also include nuts, dried fruit and fortified soya milk and other soya products, *e.g.* tofu (see also section 9.1).

6.6.2 Iron

Iron requirements are increased during pregnancy to supply the growing fetus and placenta and for the production of increased numbers of maternal red blood cells. The RNI for iron intake for adult women is 14.8 mg per day and the DRV panel did not establish any increment during pregnancy, as extra iron requirements were considered to be met through:

- cessation of menstrual losses;
- increased intestinal absorption;
- mobilisation of maternal iron stores.

The fetus accumulates most of its iron during the last trimester of pregnancy, and the iron needs of the fetus are met at the expense of maternal iron stores. Anaemia during pregnancy can increase the risk of having a LBW baby and the infant developing iron deficiency anaemia (IDA) during the first few years of life (Allen 2000) (see also section 8.3). However, it is rare that a baby is born with IDA, unless it is premature and therefore has not had enough time to accumulate enough iron during the last trimester (Thomas 2001).

A large proportion of women of childbearing age in the UK (up to 50%) have low iron stores, and are therefore at an increased risk of anaemia should they become pregnant (Buttriss *et al.* 2001). Furthermore, the recent NDNS of adults aged 19–64 years indicates that iron intakes in women in the UK have decreased over the last 15 years. Currently, 42% of 19–24-year-old women and 41% of 25–34-year-old women have an iron intake (from food sources) below the LRNI of 8 mg per day (Henderson *et al.* 2003b).

The FSA recommends that women should try to eat plenty of iron-rich foods during pregnancy (*e.g.* lean red

meat, pulses, dark green leafy vegetables, bread and fortified breakfast cereals), and also try to consume foods containing vitamin C at the same time, in order to enhance non-haem iron absorption (FSA 2005b).

Those most at risk of iron deficiency during pregnancy include women having successive births, women from lower socio-economic groups and teenagers (see section 9.2). Ideally, poor iron status should be addressed prior to conception. The COMA report does recognise that if iron stores are inadequate at the start of pregnancy, supplementation may be necessary (DH 1991). In practice, many women are prescribed iron supplements during pregnancy and may also be given dietary advice to help them increase their iron intake.

6.7 Key points

- With a few exceptions, the dietary recommendations for pregnant women are the same as for other adults.
- There is an increased requirement for energy, protein and several micronutrients during pregnancy, including thiamin, riboflavin, folate and vitamins A, C and D.
- The energy costs of pregnancy have been estimated at around 321 MJ (77 000 kcal), in a recent consultation by WHO, but this is not spread evenly throughout pregnancy. Most of the extra energy requirement is during the second and third trimesters.
- In the UK, an extra 200 kcal of energy per day is recommended during the third trimester only. However, this assumes a reduction in physical activity level, and women who are underweight or who do not reduce their activity level may require more.
- There is an increased requirement for folate throughout pregnancy to help prevent megaloblastic anaemia. In addition to the recommendation to take supplemental folic acid until the 12th week, it is advisable to consume plenty of folate-rich foods throughout pregnancy.
- Some groups of women in the UK are vulnerable to vitamin D deficiency, and it is recommended that pregnant women take a vitamin D supplement of 10 µg per day throughout pregnancy as a precautionary measure.
- There is no increment in calcium requirements during pregnancy as metabolic adaptations enable more efficient absorption and utilisation during this period. However, certain groups, such as teenagers, require more as they are still growing.
- A large proportion of young women in the UK have low iron stores, and therefore may be at risk of anaemia should they become pregnant. Furthermore, iron intakes in the UK appear to be decreasing. Pregnant women are therefore advised to consume plenty of iron-rich foods

during pregnancy and in some cases, iron supplementation may be necessary.

7 Food safety issues during pregnancy

Pregnant women are advised to pay particular attention to food hygiene during pregnancy and also to avoid certain foods, in order to reduce the risk of exposure to substances that may be harmful to the developing fetus. Potentially harmful substances include food pathogens (*e.g.* listeria and salmonella) and toxic food components [*e.g.* dioxins and polychlorinated biphenyls (PCBs)], as well as alcohol and high doses of some dietary supplements (*e.g.* vitamin A).

7.1 Vitamin A

Dietary vitamin A is obtained in two forms: as the preformed vitamin (retinol) which is found in some animal products such as dairy products, liver and fish liver oils, and as vitamin A precursors in the form of carotenes which are found in many fruits and vegetables.

It is well known that excessive intakes of vitamin A in the form of retinol may be toxic to the developing fetus. The Expert Group on Vitamins and Minerals (EVM) considered the teratogenic risks associated with retinol in their report on safe upper levels for vitamins and minerals. Vitamin A has been shown to be teratogenic (cause malformations in an embryo or fetus) in animals, and a number of epidemiological studies in humans have indicated that exposure to high levels of vitamin A during pregnancy may increase the risk of birth defects (EVM 2003). The dose threshold for prevention of birth defects is still unclear, but the lowest supplemental dose associated with teratogenic effects is 3000 µg per day (Rothman *et al.* 1995). This has been suggested as the dose threshold for teratogenicity (EVM 2003).

There have recently been concerns about the high concentrations of vitamin A present in animal liver. A typical 100 g portion has been found to contain 13 000–40 000 µg of vitamin A, which is over 18 times the RNI for pregnant women. This is thought to be due to retinol being added to animal foodstuffs to aid productivity, reproduction and immune status.

In the UK, the FSA currently advises women who are pregnant or may become pregnant to limit their intake of vitamin A in the form of retinol by avoiding liver and liver products (*e.g.* liver pâté and liver sausage). They should also avoid taking supplements containing retinol (including high dose multivitamins) and cod liver oil supplements, unless advised to do so by their GP (FSA

2005b). This reflects the previously published DH recommendations (1990).

A healthy and varied diet should provide sufficient vitamin A in the UK population. Other sources of vitamin A in the diet (*e.g.* dairy products, fat spreads, eggs, carrots and leafy vegetables) do not pose any risk of excessive intakes, and should be included as part of a healthy, balanced diet during pregnancy.

7.2 Alcohol

Alcohol consumption in high amounts has been shown to affect reproduction in women, influencing the ability to conceive and the viability of conception (Goldberg 2002). Furthermore, heavy alcohol intake in early pregnancy can have potentially damaging consequences on the embryo. Women who might become pregnant are therefore advised to avoid excessive intakes of alcohol, as any adverse effects on the fetus could occur before pregnancy has been confirmed.

Drinking heavily throughout pregnancy, *i.e.* intakes of more than 80 g of alcohol per day (equivalent to 10 units) is linked with an increased risk of fetal alcohol syndrome (FAS). This is characterised by reduced birthweight and length, including a small head size and a variety of congenital abnormalities, as well as a characteristic facial appearance. Affected children can exhibit mental retardation and stunted physical growth, although not all infants exhibit all the features of FAS (Beattie 1992).

The effects of FAS may be more severe where maternal nutritional deficiencies also exist, which frequently occurs with alcohol abuse. Intake of B vitamins is often low, while requirements may be increased due to excessive alcohol consumption. Serum concentrations of antioxidant vitamins are reduced by excessive alcohol intakes, yet these nutrients are essential in protecting against alcohol-induced free radical damage in maternal and fetal tissues. Alcohol also has a detrimental effect on the absorption and utilisation of folate, thus compounding the problem of inadequate peri-conceptual folate intakes in women who drink alcohol heavily.

There is currently a lack of consensus opinion on what is a safe level of alcohol consumption during pregnancy. The Royal College of Obstetricians and Gynaecologists (RCOG) concluded, from a review of the evidence, that consumption of more than 3 drinks per week during the first trimester of pregnancy leads to an increased risk of spontaneous abortion, and intakes over 15 units per week may have a negative effect on birthweight. The review found no conclusive evidence of any adverse effects of a level of intake below 15 units

Table 9 Caffeine contents of commonly consumed beverages and food

Beverage or food	Serving size	Caffeine content
Instant coffee	190 ml cup	Approximately 75 mg
Brewed coffee (filter or percolated)	190 ml cup	Approximately 100–115 mg
Decaffeinated coffee (instant or brewed)	190 ml cup	Approximately 4 mg
Tea	190 ml cup	Approximately 50 mg
Drinking chocolate	200 ml	1.1–8.2 mg when made up as per manufacturers' instructions
Energy drinks (containing either added caffeine or guarana)	250 ml	28–87 mg
Cola (regular and diet)	330 ml can	11–70 mg
Chocolate	50 g bar	5.5–35.5 mg

Source: COT (2001).

per week. The RCOG advises women to be cautious about their alcohol consumption during pregnancy and to consume no more than one standard drink per day (RCOG 1999).

DH (1995) currently recommends that pregnant women and those who may become pregnant should drink no more than 1–2 units of alcohol, once or twice a week at any stage of pregnancy, and should avoid binge drinking. One unit of alcohol is a small (125 ml) glass of wine, half a pint of standard-strength beer, lager or cider, or a single pub measure (25 ml) of spirit.

However, in some countries (including the USA, Canada and Australia), complete abstinence from alcohol is now recommended during pregnancy (see Mukherjee *et al.* 2005). In any case, many women develop a spontaneous distaste for alcoholic drinks from early pregnancy.

7.3 Caffeine

The Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT 2001) has recently reviewed the evidence on the reproductive effects of caffeine. They considered a large number of studies, both human and animal and including epidemiological studies, in the review.

A number of studies have shown an association between maternal caffeine intakes during pregnancy and an increased risk of both LBW and spontaneous abortion. However, the research has not found a threshold of caffeine intakes, above which there is a definite risk to pregnancy. This is partly because caffeine comes from a number of sources and different studies assume beverages to contain different amounts of caffeine. The Committee considered that there is plausible evidence of an association between caffeine intakes above 300 mg per day and LBW as well as spontaneous abor-

tion. Further studies are required, however, in order to establish whether or not there is a causal link between caffeine intake and increased risk. The Committee also noted that it is possible that other constituents in coffee, not necessarily caffeine *per se*, may pose a risk, and also that coffee and tea are not the only sources of caffeine in the diet, and may not be the main sources for all individuals.

The Committee considered that the results of other studies, that have investigated potential links between caffeine consumption during pregnancy and pre-term birth, or adverse effects on the fetus, are so far inconclusive. They concluded that there was no reliable evidence that moderate intakes of caffeine (below 300 mg/day) are associated with premature birth or other adverse effects on the fetus. In addition, the review concluded that caffeine consumption does not appear to affect male fertility, while research into its effects on female fertility is still inconclusive.

The FSA currently advises that women who are pregnant, or intend to become pregnant, should limit their caffeine intake to 300 mg per day (around four cups of coffee). Caffeine is present in a variety of foods and beverages, including cocoa, colas, energy drinks and chocolate, as well as tea and coffee. Note that the caffeine content of beverages, such as tea and coffee, varies greatly depending on brewing method, brand and strength. Caffeine is also found in a number of prescription and over-the-counter medicines, *e.g.* headache pills, cold and flu remedies, diuretics and stimulants (COT 2001). Typical caffeine contents of several foods and drinks are shown in Table 9.

In reality, as with alcohol, many women spontaneously reduce their consumption of caffeinated drinks, such as coffee, during pregnancy. The FSA also advises pregnant women to check with their GP or other health professional before taking cold and flu medicines, as many contain caffeine (FSA 2005b).

Table 10 Summary of foodborne pathogens that can cause potential harm in pregnancy

	Consequences of infection in pregnancy	Foods to avoid	Further comments
Listeriosis	Can cause miscarriage, stillbirth or severe illness in the newborn.	Pâté and mould-ripened soft cheeses, e.g. Brie, Camembert, blue-veined cheeses; unpasteurised milk and milk products.	Destroyed by heat, so re-heat ready-prepared meals thoroughly. Wash fruit and vegetables well.
Salmonella	In severe cases may cause miscarriage or premature labour.	Raw eggs or foods containing raw or partially cooked eggs, e.g. home-made mayonnaise.	Cook eggs until white and yolk are solid. Cook all meat, particularly poultry, thoroughly.
Toxoplasmosis	In rare cases can lead to severe fetal abnormalities.	Raw or undercooked meat; unpasteurised milk and milk products.	Avoid contact with soil or cat liver trays by wearing gloves.
Campylobacter	May cause premature birth, spontaneous abortion or stillbirth.	Raw or undercooked poultry; unpasteurised milk and milk products.	Domestic pets and soil can also be a source of infection.

7.4 Foodborne illness

The following food pathogens can cause potential harm to the developing fetus during pregnancy. This information is also summarised in Table 10.

7.4.1 Listeriosis

Listeriosis is a flu-like illness caused by the bacteria *Listeria monocytogenes*. Although listeriosis is rare in the UK, if it occurs during pregnancy, it can cause miscarriage, stillbirth or severe illness in the newborn. Pregnant women are therefore advised to avoid foods in which high levels of the bacteria have sometimes been found. This includes pâté and soft cheeses which are mould-ripened, e.g. Brie, Camembert and blue-veined cheeses. Hard cheeses such as cheddar and other cheeses made from pasteurised milk pose no risk, including cottage cheese, mozzarella and processed cheese spreads (DH 2005). Unpasteurised milk and unpasteurised milk products should also be avoided.

Listeria bacteria are destroyed by heat and therefore, as with the general population, pregnant women are advised to re-heat ready-prepared meals thoroughly, particularly if they contain poultry. Ready-prepared meals which will not be re-heated should also be avoided, e.g. purchased salads, quiches and cold meat pies. It is also advisable to wash fruit and vegetables very thoroughly, especially if they are to be eaten raw, in order to minimise risk.

7.4.2 Salmonella

Salmonella is a major cause of food poisoning in the UK, and in severe cases, it may cause miscarriage or premature labour in pregnant women (Thomas 2001). Salmonella poisoning is most likely to come from raw eggs or

undercooked poultry, therefore pregnant women are advised to avoid eating raw eggs or foods containing raw or partially cooked eggs, e.g. home-made mayonnaise. Eggs should be cooked until the white and yolk are solid. All meat, in particular poultry, needs to be thoroughly cooked, and pregnant women should take particular care when handling these foods. Raw foods should be stored separately from cooked foods in the fridge (so that raw foods cannot drip on cooked foods) in order to avoid the risk of cross-contamination.

7.4.3 Toxoplasmosis

Toxoplasmosis is a condition caused by the organism *Toxoplasma gondii* which can be found in raw meat, unpasteurised milk and cat faeces. Infection in pregnancy can, in rare cases, lead to severe abnormalities in the fetus, including blindness and mental retardation (Thomas 2001). Pregnant women are advised to avoid raw or undercooked meat and unpasteurised milk and milk products (particularly goat's milk) as a precaution. In addition, they should avoid contact with soil or cat litter trays by wearing gloves when gardening or changing cat litter. Pregnant women should be particularly cautious about food hygiene if cats come into their kitchen.

7.4.4 Campylobacter

Campylobacter is a genus of pathogenic organisms which are a common cause of food poisoning in the UK. Infections during pregnancy have been associated with premature birth, spontaneous abortion and stillbirths. Common sources of infection include poultry, unpasteurised milk, untreated water, domestic pets and soil. As with other sources of infection, observing good hygiene practices helps to reduce risk.

7.5 Fish

The FSA issued new advice on oil-rich fish consumption for the general population in 2004, including specific advice for certain groups such as pregnant women. This new advice was based on a joint report from the SACN and the COT which considered the risks and benefits of fish consumption, in particular oil-rich fish (SACN 2004). The new advice recommends, for the first time, maximum intakes of oil-rich fish for different groups of the population.

The current advice for the general population is to consume at least two portions of fish per week, one of which should be oil-rich (DH 1994). This recommendation also applies to pregnant and breastfeeding women (and women who may become pregnant), but with a limit of no more than two portions of oil-rich fish per week.

The basis for these recommendations is that the consumption of fish, particularly oil-rich fish, confers significant health benefits, in terms of a reduction in the risk of CVD. This is thought to be due to the long-chain *n*-3 PUFAs found in fish, levels of which are particularly high in oil-rich fish. In addition, these long-chain fatty acids are required for the development of the central nervous system in the fetus and young infant, so are important for both pregnant and breastfeeding women. However, the FSA has set a maximum limit on oil-rich fish consumption due to the risk of exposure to pollutants, such as dioxins and PCBs, which have been found in oil-rich fish. These are persistent compounds that may accumulate over time in the body and could have adverse health effects if consumed at high levels over a long period of time.

Pregnant women, and those who may become pregnant, are also advised to avoid marlin, shark and swordfish due to the risk of exposure to methylmercury, which at high levels can be harmful to the developing nervous system of the fetus (see Theobald 2003). For the same reason, the FSA also advises pregnant women to limit their intake of tuna to no more than two portions of fresh tuna per week *or* four medium-sized tins of tuna per week (FSA 2005b). Mercury, in the form of methylmercury, is concentrated up the food chain and therefore found in highest amounts in large, predatory fish; the highest concentrations have been found in shark, marlin and swordfish.

7.6 Food allergy

Peanut allergy is increasing in children, and is the cause of some concern, as allergy to peanut protein can cause

anaphylaxis (BNF 2002). The cause of peanut allergy is still unclear, but the use of peanuts and peanut oil has increased in the British diet over the past few years, and it has been suggested that exposure to peanuts at a young age may cause the allergy. The use of skin preparations containing peanut oil has also been implicated (Lack *et al.* 2003).

Infants whose parents have a history of allergic disease are more likely to develop allergies themselves. It is thought that in such infants, sensitisation to foreign proteins that cross the placenta may occur during pregnancy (or via breastmilk during lactation), and therefore it has been suggested that maternal avoidance of potentially allergenic foods during pregnancy and lactation may help prevent allergy in infants (Goldberg 2002). However, the evidence that prenatal exposure leads to subsequent development of food allergy is weak (BNF 2002).

Unless there is a strong family history of allergic disease, there is currently no convincing evidence that avoidance of these foods during pregnancy is protective against childhood allergy, even in high-risk infants (Goldberg 2002). It has also been suggested that exposure to foreign proteins via the placenta is important in helping the baby to develop a tolerance to the many foreign proteins in the environment (BNF 2002). Furthermore, any diet that excludes specific foods may be restrictive in terms of nutrient intake, and therefore should only be followed under medical supervision (although avoiding peanuts is considered to be less restrictive than other diets, *e.g.* excluding wheat or dairy).

Current advice is that if there is a strong family history of atopic disease (*i.e.* if either parent or a previous child has suffered from hay fever, asthma, eczema or other allergy), then it may be advisable to avoid peanuts or foods containing peanuts during pregnancy and while breastfeeding, in order to reduce the risk of the infant developing a peanut allergy. Also, in cases where there is a familial history of allergic disease, peanuts and peanut-containing foods should not be given to children before the age of 3 years (FSA 2002b).

7.7 Key points

- Excessive intakes of vitamin A, in the form of retinol, are toxic to the developing fetus and may cause birth defects; therefore, pregnant women, or those who may become pregnant, are advised to limit their intake of vitamin A by avoiding liver and liver products and supplements containing retinol.
- Alcohol consumption in high amounts can be potentially damaging to the developing embryo and may

cause fetal alcohol syndrome. The DH advises pregnant women, and those who may become pregnant, to limit their alcohol consumption to no more than 1–2 units, once or twice per week.

- High intakes of caffeine during pregnancy may increase the risk of LBW or miscarriage, and therefore pregnant women, or those who may become pregnant, are advised to limit their intake of caffeine to 300 mg per day.
- Pregnant women are advised to pay particular attention to food hygiene and to avoid certain foods during pregnancy in order to minimise the risk of food poisoning from potentially harmful pathogens, such as listeria and salmonella.
- Pregnant women and those who may become pregnant are advised to consume no more than two portions of oil-rich fish per week, to avoid exposure to dioxins and PCBs. They should also avoid shark, marlin and swordfish, and limit their intake of tuna to prevent exposure to methylmercury, which can be harmful to the developing fetus.
- The incidence of peanut allergy in children is on the increase; however, there is a lack of evidence that prenatal exposure to peanuts causes the development of peanut allergy in infants. Pregnant women are currently only advised to avoid peanuts during pregnancy if there is a strong family history of allergic disease.

8 Diet-related conditions during pregnancy

8.1 Nausea and vomiting and changes in taste and appetite

Symptoms of morning sickness, nausea and vomiting (particularly in the first trimester) are reported to occur in around half to three-quarters of pregnant women (Buttriss *et al.* 2001). The causes of these symptoms are unknown, but a variety of triggers have been documented, including smells of foods, perfume and cigarette smoke. Eating small, high-carbohydrate snacks at frequent intervals (*e.g.* 2–3 hourly) often provides relief, although the reasons for this are unclear.

Changes in taste and appetite are also common in pregnancy. Some women experience increases in appetite which may be caused by hormonal changes or because of the removal of energy substrates from maternal blood by the fetus. The development of cravings or aversions to foods is also often reported, with the most common cravings being for dairy products and sweet foods. Common aversions include tea and coffee, alcohol, fried foods and eggs and, in later pregnancy, sweet foods (Thomas 2001). In practice, women usually learn

quite quickly which foods to avoid, and this is unlikely to affect nutritional status as long as the overall diet is nutritionally balanced (Goldberg 2003).

Pica is a condition where non-food substances such as soap, coal and chalk are craved and consumed. The reasons for the development of this condition are unknown, but there is no clear evidence that it has any link with mineral deficiencies (Thomas 2001). The incidence of pica in the UK appears to have decreased in recent years (Buttriss *et al.* 2001).

8.2 Constipation

It is quite common for women to suffer from constipation during pregnancy. The causes are complex, but are probably due to physiological effects on gastrointestinal function caused by pregnancy, as well as a decline in activity and changes in the diet (Thomas 2001).

Pregnant women are advised to increase their intake of fibre (particularly wholegrain cereals), drink plenty of fluids and take gentle exercise in order to alleviate the condition. Other considerations include the use of dietary bulking agents and changing the type of iron supplement used, as iron supplements may sometimes aggravate the symptoms of constipation.

8.3 Anaemia

Anaemia can be defined as ‘a reduction in the oxygen-carrying capacity of the blood which may be due to a reduced number of red blood cells, a low concentration of haemoglobin (Hb) or a combination of both’ (Lloyd & Lewis 1996). Anaemia in pregnancy affects both the mother and the fetus. In the mother, it may lead to symptoms such as breathing difficulties, fainting, fatigue, tachycardia (excessive heartbeat rate) and palpitations. It may also lead to reduced resistance to infection and the risk of haemorrhage before or after the birth. In the fetus, anaemia can cause intrauterine hypoxia (low oxygen levels) and growth retardation, although the effects of anaemia can be difficult to separate from other factors, such as social class and smoking (Stables 2000).

Most cases of anaemia during pregnancy are caused by iron deficiency; however, it is also associated with folate deficiency, blood loss and inherited conditions such as sickle cell anaemia and thalassaemia (Schwartz & Thurnau 1995). Iron deficiency is fairly common during pregnancy; however, haematological changes during pregnancy, which reflect haemodilution, can make it difficult to correctly diagnose. The WHO criteria for diagnosis of anaemia in pregnancy is Hb < 11 g/dl; however,

in practice, many doctors only investigate women with Hb < 10 or 10.5 g/dl (Stables 2000).

Iron deficiency anaemia (IDA) in pregnancy is a risk factor for pre-term delivery and subsequent LBW. There is also increasing evidence that maternal iron deficiency in pregnancy results in reduced fetal iron stores that may last well into the first year of life. This may lead to IDA in infancy which could have adverse consequences on infant development (Allen 2000). IDA is usually treated with oral iron supplements, but intramuscular injection or intravenous infusion can also be given if necessary. In practice, many women are prescribed iron supplements at some point during pregnancy, even though IDA is difficult to diagnose. Iron supplements should be prescribed with caution, however, as they may cause side effects such as nausea and constipation.

Folate deficiency in pregnancy can, in severe cases, lead to megaloblastic anaemia. This is most likely to occur in late pregnancy or the first few weeks after the birth. Folate deficiency may lead to pallor, fatigue and gastrointestinal symptoms such as nausea, vomiting and diarrhoea. Megaloblastic anaemia can usually be treated with folic acid supplementation of 5–15 mg of folic acid daily (Stables 2000); however, this should be considered in relation to the current recommendation to take folic acid supplements until the 12th week of pregnancy to protect against NTDs (see section 5.4).

8.4 Gestational diabetes

Gestational diabetes (GDM) is the most common metabolic disorder of pregnancy and occurs in around 2% of all pregnancies, usually in the last trimester. It is often asymptomatic and is diagnosed by abnormal blood glucose results, usually after a glucose tolerance test. Following delivery, glucose metabolism may return to normal or may stay impaired, and in some cases, maternal type 2 diabetes can develop. GDM is associated with an increased risk of perinatal morbidity and mortality (Stables 2000).

GDM is more common among women from Asia and the Middle East, and there is an increased incidence in overweight and obese women, as well as older women and those from lower socio-economic groups. GDM leads to an increased risk of complications for both the mother and the fetus, including macrosomia (birthweight >4.5 kg) and a greater likelihood of difficulties during labour. There is also an increased risk of developing type 2 diabetes in both the mother and infant, although the risk can be reduced by maintaining a healthy body-weight, taking regular physical activity and following a healthy, balanced diet (see Dornhorst & Rossi 1998).

If GDM is diagnosed during pregnancy, treatment is aimed at controlling blood glucose levels, with additional fetal monitoring in order to try to decrease the incidence of macrosomia. Dietary management is usually sufficient, but occasionally insulin is also necessary. There is currently some controversy over the dietary guidelines for the management of GDM and a lack of good-quality trials in this area. The limited evidence available indicates that dietary changes are effective in improving maternal hyperglycaemia and reducing the risk of accelerated fetal growth. Dietary recommendations include consuming regular meals and snacks that contain higher levels of slowly digestible carbohydrate. As many women with GDM are overweight or obese, the diet must also avoid excessive weight gain, which can further compromise pregnancy outcomes (Dornhorst & Frost 2002).

8.5 Hypertensive disorders

Pregnancy-induced hypertension (PIH) is a common condition specific to pregnancy that mainly occurs after the 28th week of gestation and disappears after delivery. This is sometimes confused with a condition known as pre-eclampsia, which is more severe and is also associated with the appearance of the protein albumin in the urine (in the absence of other causes, *e.g.* renal disease or pre-existing hypertension). Pre-eclampsia usually occurs towards the end of pregnancy and causes high blood pressure in the mother.

The aetiology of pre-eclampsia is unknown, but obesity appears to be a risk factor (O'Brien *et al.* 2003). It is an inflammatory condition involving endothelial dysfunction, and it has been suggested that certain other dietary factors may be linked. A number of trials have indicated that supplementation with antioxidants (*e.g.* vitamins C and E) may reduce the risk of pre-eclampsia, although these trials are of variable quality (Rumbold *et al.* 2005). There is also some evidence from randomised controlled trials that calcium supplementation during pregnancy may help reduce the risk of pre-eclampsia (Bucher *et al.* 1996), but not all trials have shown an effect. Further investigation is therefore needed into whether this condition can be successfully treated or prevented with dietary changes or supplementation.

8.6 Key points

- Symptoms of morning sickness, nausea and vomiting are commonly reported in pregnancy. Changes in appetite and taste (*e.g.* cravings or aversions to foods) also frequently occur. As long as the diet is balanced overall,

such changes are unlikely to have any adverse effect on nutritional status.

- It is also common for women to suffer from constipation during pregnancy; increasing fibre intake, drinking plenty of fluids and taking gentle exercise can help alleviate the condition.
- Anaemia in pregnancy has effects on both the mother and the fetus, and may lead to a variety of symptoms. In most cases, it is caused by iron deficiency, which is fairly common during pregnancy but can be difficult to diagnose. IDA is a risk factor for both LBW and pre-term delivery, and is usually treated with oral iron supplementation.
- GDM is the most common metabolic disorder of pregnancy, occurring in around 2% of all cases. GDM is more common in certain ethnic groups and women who are overweight or obese. It can lead to an increased likelihood of complications, such as macrosomia and labour difficulties. Dietary management is usually sufficient in treating the condition, but more research is needed in this area.
- Hypertensive disorders, such as pre-eclampsia, can sometimes occur towards the end of pregnancy. Obesity is a risk factor for pre-eclampsia, but there is some evidence that other dietary factors may be linked. Research is ongoing into whether supplementation during pregnancy (e.g. with antioxidant vitamins or calcium) may help prevent this condition.

9 Issues for specific groups

9.1 Vegetarians and vegans

As has already been highlighted, there is an increased requirement for energy, protein and some micronutrients during pregnancy, including thiamin, riboflavin, folate and vitamins A, C and D (DH 1991). Typically, a vegetarian or vegan diet can meet the increased demand for energy and protein during pregnancy, but there may be problems in trying to achieve the recommended intake of some vitamins and minerals, especially for vegans, due to dietary restrictions.

The four main categories of vegetarianism are as follows:

'Partial' or 'semi' vegetarians consume plant and dairy foods, as well as eggs and fish, may consume poultry, but avoid other types of meat.

Lacto-ovo-vegetarians consume plant and dairy foods and eggs, but avoid all meat and fish.

Lacto-vegetarians consume plant and dairy foods, but avoid all meat, fish and eggs.

Vegans consume only foods of plant origin, and exclude all meat, fish, dairy foods, eggs or any foods made from animal products, such as gelatine and suet.

A study conducted by Draper *et al.* (1993) in non-pregnant vegetarians and vegans found that in partial vegetarians and lacto-ovo-vegetarians, mean intakes of micronutrients met the UK RNI. However, in vegans, intakes of riboflavin, vitamin B₁₂, calcium and iodine were below the RNI. This highlights the fact that vegan women may be vulnerable to low intakes of some important nutrients during pregnancy and the need for adequate dietary planning during this time. Vegetarians and vegans may also have low intakes of iron, zinc and vitamin D as a result of excluding meat from the diet (Philips 2005).

Several studies have looked at associations between following a vegetarian or vegan diet during pregnancy and birth outcome, but the results of these studies are not always consistent. For example, Drake *et al.* (1998) found no difference in length of gestation, birthweight, birth length or head circumference between the babies of lacto-ovo-vegetarians, fish-eaters and meat-eaters. However, Sanders (1995) found that white, vegan mothers had lower birthweight babies compared with women from the rest of the population.

Reddy *et al.* (1994) studied the birth outcomes of pregnant vegetarian women of Asian backgrounds living in the UK, and found that offspring born to these mothers had a lower birthweight, smaller head circumference and shorter body length than infants of white omnivores. In addition, duration of pregnancy was shorter, onset of labour earlier and emergency caesarean sections were more common than in white, caucasian women, even after adjusting for confounding variables such as maternal age, height and gestational age. It has been suggested that the lower birthweights seen in vegetarian mothers may be attributable to poor nutritional status due to an inadequate intake of iron, folate or vitamin B₁₂, but further research in this area is needed (Philips 2005).

The type of dietary advice that is applicable to vegetarians and vegans during pregnancy depends, to a certain extent, on the type of vegetarian or vegan diet followed. However, with regard to food safety, pregnant vegetarians and vegans should adhere to the same dietary advice as that given to all pregnant women (see section 7). Although vegetarian and vegan diets provide the potential for low intakes of certain nutrients during pregnancy, it should still be possible for vegetarians and vegans to meet all their nutrient requirements, as long as the nutrients absent, due to the avoidance of dairy or foods of animal origin, are replaced by other sources or

Table 11 Vegetarian and vegan sources of selected nutrients

Nutrient	Vegetarian or vegan sources	Further comments
Riboflavin (B ₂)	Dairy products, eggs, yeast extract, wheat germ, almonds, soya beans, tempeh, fortified foods including breakfast cereals and soya milk, mushrooms and seaweeds	
Vitamin B ₁₂	Dairy products, eggs, fortified foods including yeast extract, soya milk, textured soya protein and breakfast cereals.	This vitamin only occurs naturally in foods of animal origin. Although there is no increment in the RNI for pregnancy, vegetarians and vegans need to ensure they receive adequate amounts from their diet. Vegans and those who avoid animal products completely, need to include a source of vitamin B ₁₂ in their diet either in supplement form or from fortified foods.
Vitamin D	Dairy products, eggs, fortified foods including margarine and other fat spreads, breakfast cereals, soya milk and other soya products.	The main source of vitamin D is from the action of sunlight on the skin, so exposure to 'gentle' sunlight in the summer months (April to October) is important in maintaining vitamin D status. Vitamin D supplements (10 µg per day) are recommended for all pregnant women.
Calcium	Milk and dairy products, green leafy vegetables, pulses, soybeans and fortified foods, e.g. bread and soya milk, tofu, nuts and dried fruit.	Milk and dairy foods are the best dietary sources of calcium as they have a high calcium content and the bioavailability is also high.
Iron	Pulses, dark green leafy vegetables, and fortified foods including breads and fortified breakfast cereals, dried fruit, nuts and seeds.	Iron from plant foods is in the non-haem form which is less bioavailable than the haem form found in animal foods. The absorption of non-haem iron is enhanced by consuming foods containing vitamin C at the same time as iron-containing foods. However, absorption is inhibited by tannins (in tea), phytates (in cereals and pulses) and fibre.
Iodine	Iodised salt, milk and seaweeds.	The level of iodine found in plant foods varies depending on how much iodine is present in the soil where the plants are grown.
Zinc	Dairy products, eggs, bread and other cereal products, pulses, beans, nuts, seeds, green vegetables and fortified breakfast cereals.	Vegetarian and vegan diets typically contain adequate amounts of zinc. It is thought that adaptation to a vegetarian or vegan diet occurs over time, resulting in increased absorption of zinc. However, zinc absorption is inhibited by phytates (in cereals and pulses) which are frequently associated with vegetarian and vegan diets.
<i>n</i> -6 PUFAs	Sources of linoleic acid include vegetable oils, e.g. sunflower oil, corn oil and soyabean oil and spreads made from these.	Plasma levels of arachidonic acid (AA) have been found to be higher in vegetarians and vegans than omnivores, and it is thought that sufficient AA can be synthesised from linoleic acid.
<i>n</i> -3 PUFAs	Sources of alpha-linolenic acid include linseed (or flaxseed), rapeseed oil, walnut oil, soyabean oil and blended vegetable oils, tofu and walnuts.	Conversion of alpha-linolenic acid to the long-chain <i>n</i> -3 fatty acids EPA and DHA is limited. The only vegan sources of EPA and DHA are some seaweeds, although algal supplements of DHA are now available.

DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; PUFAs, polyunsaturated fatty acids, RNI, Reference Nutrient Intake.

supplements (University of Sheffield 2004). Table 11 lists suitable, alternative food sources for nutrients that may be inadequate in some vegetarian and vegan diets and that are important during pregnancy.

9.2 Teenage pregnancy

The UK has one of the highest rates of teenage pregnancy in Europe, although rates have declined slightly since 1998. In England, the current teenage conception rate is 42.1 per 1000 girls aged 15–17. In 2003 there were

39 571 under 18 conceptions, of which 46% led to legal abortion (Office for National Statistics 2005). In general, studies have shown that teenage pregnancy is associated with lower gestational weight gain and an increased risk of LBW, PIH, pre-term labour, IDA and maternal mortality (Felice *et al.* 1999). However, many studies in developed countries have been criticised for not controlling for factors such as pre-pregnancy BMI, length of gestation, ethnicity, alcohol intake and smoking, which have been shown to be associated with the risk of LBW (Goldberg 2002).

Table 12 Percentages of teenage girls with intakes below the lower reference nutrient intake (LRNI), for selected nutrients

Nutrient	Girls aged 11–14 years (%)	Girls aged 15–18 years (%)
Vitamin A	20	12
Riboflavin	22	21
Folate	3	4
Calcium	24	19
Iron	45	50
Zinc	37	10

Source: National Diet and Nutrition Survey of young people aged 4–18 years (Gregory *et al.* 2000).

Table 13 Percentages of teenage girls with poor nutrient status

Parameter	Girls aged 11–14 years (%)	Girls aged 15–18 years (%)
Haemoglobin (<12 g/dl)	4	9
Ferritin (<15 g/l)	14	27
Red cell folate (<350 nmol/l)	11	14
(<425 nmol/l)	28	39
Serum folate (<6.3 nmol/l)	1	1
(<10 nmol/l)	6	14
Vitamin D (<25 nmol/l)	11	10

Source: National Diet and Nutrition Survey of young people aged 4–18 years (Gregory *et al.* 2000).

The NDNS of young people aged 4–18 years found that a considerable percentage of adolescent girls had nutrient intakes below the LRNI (Gregory *et al.* 2000). Table 12 illustrates the percentage of girls aged 11–18 years with intakes below the LRNI for a range of important nutrients (although these proportions may be slightly overestimated due to the problem of underreporting). These data are also corroborated by serum measurements which show that a high proportion of teenage girls have poor iron, folate and vitamin D status (Table 13).

Furthermore, teenage pregnancy occurs at a time when the maternal body already requires extra nutrients for growth and development, so there is potential competition for nutrients. It is therefore possible that maternal growth and development may be compromised, with priority given to the developing fetus. For this reason, a higher gestational weight gain is recommended for pregnancy in adolescence in the USA (IOM 1990; Gutierrez & King 1993). The availability of nutrients to the developing fetus is an important factor in determining optimal birth outcome, and it has also been suggested that there is a reduced flow of nutrients to the fetus in teenage pregnancy due to immature placental development (Goldberg 2002).

One nutrient of particular importance during teenage pregnancy is calcium, as a rapid increase in bone mass occurs during the adolescent years so the maternal skeleton is still developing. Although some physiological adaptations take place which help to meet additional calcium requirements during pregnancy, teenage girls require more calcium than adults for bone development. The RNI for calcium for girls aged 11–18 years is 800 mg per day, compared with 700 mg per day for adult women (DH 1991).

As indicated above, iron intakes have been found to be below the LRNI in up to half of teenage girls in the UK, and many teenage girls have low iron stores (Tables 12,13). This is attributed to low iron intakes because of a poor diet, dieting to lose weight or vegetarianism, together with the demands of adolescent growth and the onset of menstruation. Maternal IDA is a risk factor for pre-term delivery and subsequent LBW (see section 8.3). Therefore, it is important to ensure an adequate intake of iron throughout pregnancy, particularly in teenagers. Iron supplements may also sometimes be prescribed, if necessary.

Folate intake is a particular concern in teenage pregnancies. As already outlined, inadequate folate intake is associated with an increased risk of NTDs in the developing fetus, and therefore folic acid supplements are recommended prior to conception and until the 12th week of pregnancy. This is often a problem in relation to teenage pregnancies, as around 75% are unplanned (Goldberg 2002). Folic acid supplements are therefore often not taken prior to conception or in the early stages of pregnancy, either because pregnancy is undetected or because the importance of taking folic acid is not known. Furthermore, menstruation is often irregular initially in teenage girls, which compounds the problem of detecting pregnancy during the critical early stages, when folate is important. Also, some teenage girls are preoccupied with their weight, or may try to restrict weight gain in order to conceal the fact that they are pregnant. Research has also shown that dieting behaviour during pregnancy, including weight-loss diets, fasting diets and eating disorders, is associated with an increased risk of NTDs (Carmichael *et al.* 2003).

Adolescent pregnancy therefore presents many challenges for health professionals, and this section has highlighted the importance of providing good dietary advice and support for teenagers who become pregnant.

9.3 Dieting during pregnancy

For women with a normal pre-pregnancy BMI, an average weight gain of 12 kg (range 10–14 kg) during preg-

nancy is associated with optimal maternal and fetal outcomes. This gain in weight is natural and should not be avoided or minimised, as low gestational weight gain is linked with poor fetal growth and development and an increased risk of having a LBW baby (Anderson 2001; Buttriss *et al.* 2001). In addition, a low maternal weight gain is associated with an increased risk of pre-term delivery, particularly for women who were underweight or of an average weight, before pregnancy (Schieve *et al.* 2000; Mann & Truswell 2002).

Studies looking at dieting behaviours, including restricting food intake, dieting to lose weight, fasting diets and eating disorders, found this behaviour to be associated with a higher risk of NTDs in the first trimester (Carmichael *et al.* 2003). A study by Franko and Spurrell (2000) found that eating disorder behaviour during pregnancy was also associated with higher rates of miscarriage, LBW and post-partum depression. Abraham (1994) studied the eating behaviour and attitudes to bodyweight of women who had recently given birth to their first child, and found that women who reported suffering from 'disordered eating' during pregnancy were more likely to have given birth to a LBW infant.

Overall, there is a consensus that dieting during pregnancy should be discouraged (Anderson 2001). Pregnancy is not a suitable time to restrict the diet, or to lose weight, as appropriate maternal weight gain is important for the mother, as well as the fetus, to ensure adequate fetal growth and development occurs.

9.4 Key points

- Vegetarians and vegans can have difficulty meeting their requirements for certain micronutrients during pregnancy, particularly riboflavin, vitamin B₁₂, calcium, iron and zinc.
- Studies comparing birth outcomes (*e.g.* birthweight, length of gestation) in vegetarian or vegan mothers and omnivores, have so far not produced consistent results.
- Most vegetarian and vegan women should be able to meet their nutrient requirements during pregnancy with careful dietary planning. However, those on very restricted diets may also need to consume fortified foods or supplements.
- Teenage pregnancy occurs at a time when the maternal body already has high nutrient requirements for growth and development, and therefore there is potential competition for nutrients. Moreover, a large proportion of teenage girls have low intakes of a range of nutrients that are important during pregnancy.

- There are a number of nutrition-related problems associated with adolescent pregnancy, including low gestational weight gain and an increased risk of a number of complications, *e.g.* LBW and IDA.
- The main nutrients of concern with regard to teenage pregnancy are calcium, iron and folate. In particular, folic acid supplements are often not taken prior to conception either because the pregnancy is unplanned, or because teenagers are unaware of the importance of taking folic acid. Teenage pregnancy therefore presents particular challenges for health professionals.
- Dieting during pregnancy has been associated with an increased risk of NTDs and a number of other potential complications. An appropriate amount of weight gain during pregnancy is important for fetal development and a healthy pregnancy outcome. Pregnancy is therefore not an appropriate time for dietary restriction and dieting should be strongly discouraged.

10 Conclusions and recommendations

A healthy and varied diet that contains adequate amounts of energy and nutrients is essential for optimum fetal growth and development and to maintain good maternal health. There is an increased requirement for energy, protein and several micronutrients during pregnancy. However, in many women, intakes of a range of nutrients are below the LRNI, suggesting they are likely to be inadequate. In particular, a high proportion of women of child-bearing age have low iron stores, and intakes of iron have been declining over recent years. The importance of good dietary advice during pregnancy to encourage women to consume a healthy, balanced diet, in particular plenty of iron- and folate-rich foods, should therefore not be underestimated. In addition, a folic acid supplement (400 µg/day) is recommended prior to and up to the 12th week of pregnancy, and a vitamin D supplement (10 µg/day) is recommended throughout pregnancy.

As well as following a healthy, balanced diet, staying physically active is also very important during pregnancy. Exercise can help prevent excess weight gain during pregnancy and help the mother return to a normal weight (BMI of 20–25) after the birth. A number of trials have examined the effects of maternal exercise on fetal growth and pregnancy outcome, although some are of poor quality. However, there is little evidence to suggest that regular, moderate intensity exercise has any adverse effects on the health of the mother or the infant. Studies do suggest that regular aerobic exercise during pregnancy helps improve or maintain physical fitness and body image (Kramer 2002). It is recommended that pregnant women should try to keep active on a daily

basis, e.g. with regular walking. Swimming is a suitable form of exercise, and is particularly recommended during late pregnancy. Strenuous physical activity should be avoided, especially in hot weather, and pregnant women are advised to drink plenty of fluids to avoid becoming dehydrated (DH 2005).

Certain population groups may require closer attention during pregnancy, including teenage girls, women from certain ethnic groups and women from lower socio-economic backgrounds. In particular, teenage pregnancy presents distinct nutritional challenges as teenagers are still growing, and therefore there is potential competition for nutrients between the mother and developing fetus. Moreover, a large proportion of teenage girls have low intakes of a number of important nutrients and have been found to have poor iron, folate and vitamin D status. Folate intake is a particular concern as most teenage pregnancies are unplanned and, despite government campaigns, only a small proportion of teenagers seem to be aware of the importance of taking folic acid.

There is now evidence from elsewhere in the world, that mandatory fortification of flour with folic acid can lead to substantial reductions in the incidence of NTD-affected pregnancies and the government's SACN has recently published a report recommending the introduction of mandatory fortification of flour with folic acid in the UK (SACN 2005). If this goes ahead, it should help address some of the problems of marginal folate status in UK women and inadequate uptake of the folic acid recommendations, and ultimately help to reduce the incidence of NTD-affected pregnancies in the UK.

Further information

For further, practical information and advice on healthy eating during pregnancy, see:

The Food Standards Agency website:
<http://www.eatwell.gov.uk>;

The Pregnancy Book: March 2005 edition.
Available from the Department of Health website:
<http://www.dh.gov.uk>.

For further information on physical activity in pregnancy, see: <http://www.bupa.co.uk>.

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