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Nutrition in Pregnancy

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1. Prepregnancy diet

A healthy pregnancy may depend as much on prepregnancy diet and related body composition as it does to nutrients consumed during the pregnancy. It is well known that women with a body composition less than 22% fat rarely ovulate[1] and the same is true of women with a normal body mass index (BMI) exposed to acute famine or starvation, where ovulation is suspended very rapidly. Anovulatory infertility is a feature of underweight but is also seen with a high frequency in women who are overweight in the preconceptional period and indeed the outcomes of pregnancy follow a U-shaped curve, with more adverse outcomes in women entering pregnancy underweight and those entering pregnancy overweight or obese compared with those in the normal weight range. Prepregnancy counselling might reasonably, therefore, include dietary manipulation to either raise or reduce the BMI as appropriate, particularly in those found to have anovulatory infertility.

Marginal to severe folate deficiency appears to be present in 5% of the general population[2] and in early pregnancy.[3] Its association with neural tube defects and dietary advice to raise the intake of folates with a dietary supplement of folic acid (400 micrograms/day) is standard prepregnancy advice.

2. Angiogenesis inhibitors

Homeostasis of nutrient levels is altered in pregnancy with (as a general rule) water-soluble nutrients occurring in the maternal plasma in lower levels than in the nonpregnant state and the opposite for fat-soluble nutrients. Glucose crosses the placenta by facilitated diffusion and provides at least 75% of fetal energy requirements. Amino acids are transferred across the placenta against concentration gradients and fatty acids cross the placenta by simple diffusion. Synthesis of fats takes place in the fetal compartment. Ketone bodies produced by maternal lipolysis (which is enhanced, particularly during overnight fasting in pregnancy) cross the placenta freely by diffusion. Carbon from ketone bodies is incorporated into fetal tissue and ketones also have a role in energy production.

3. Micronutrients

3.1 Vitamins

The fat-soluble vitamins A and D cross the placenta freely by diffusion. Vitamin E and vitamin K are transferred relatively poorly across the placenta and levels in the fetus and newborn are lower than in the mother, although there appears to be no functional significance to this.

For the water-soluble vitamins, vitamin C is transferred across the placenta by facilitated diffusion and appears in higher concentrations in the fetal circulation than maternal circulation. It competes for placental receptors with glucose but even in maternal hyperglycaemia there does not seem to be evidence of hypovitaminosis C in the fetus.

The B vitamins are handled differently at the placenta. Folate-binding receptors maintain a high fetal maternal concentration gradient with a possible final transfer to the fetal circulation occurring down a concentration gradient. There are also placental receptors for vitamin B12. Piridoxine is passively transported across the placenta but thiamine and riboflavin are actively transported with higher concentrations in the fetus than in the mother.

3.2 Minerals and trace elements

Calcium is actively transported across the placenta and levels in the fetus are higher than in the mother. Magnesium is also actively transported across the placenta but there does not seem to be a clear relation-

ship between maternal and fetal concentrations. Zinc is actively transported bound to albumin and is found in significantly higher concentration in the fetal than the maternal circulation. Iron transfer to the fetus is marked, particularly in late pregnancy when the fetal demands are greatest, and there are tranferrin receptors on the placenta which facilitate the transfer of transferrin-bound iron, by endocytosis.

Although a series of apparently efficient transfer mechanisms from the mother to the fetus are in place, there are anticipatory changes in these physiological phenomena. Maximum demand for new tissue accretion occurs in the late second and early third trimesters but the homeostatic changes to facilitate nutrient transfer are for the most part established by 10–12 weeks of amenorrhoea.

4. Energy costs of pregnancy

A major concern for nutritionists and obstetricians advising pregnant women is the relationship between energy consumption and fetal growth and development, and indeed the relationship between pregnancy weight gain and pregnancy outcomes.

Although the American National Institutes of Health have for a long time suggested that because there is a relationship between gestational weight gain and outcomes such as preterm birth, birth weight and associated perinatal morbidity and mortality, regular weighing accompanied by dietary manipulation to bring weight gain up or down into the 'normal' range is likely to be beneficial to the outcomes of pregnancy.[4] Unfortunately, this hypothesis has never been tested in any randomised controlled trial and there are considerable doubts as to the value of this type of weight gain monitoring.[5] In the UK, the National Institute for Health and Clinical Excellence does not therefore recommend routine monitoring of weight gain unless clinical management is likely to be influenced.[6] A low weight gain may be associated with fetal growth restriction and reduced liquor volume and, to that extent, the poor outcomes for pregnancy associated with a low weight gain may be self-fulfilling. Similarly, in women who develop pre-eclampsia, a high weight gain associated with maternal fluid retention might be falsely reassuring. Detailed calculations of the components of average pregnancy weight gain and fetal body composition were elaborated some years ago by Hytten *et al*. In summary, total tissue accretion was uterus: 0.9 kg, breasts: 0.4 kg, blood: 1.2 kg, extra-cellular fluid: 1.2 kg, fat: 3.5 kg. Combining this maternal tissue accretion with the weight of the average products of conception produces a mean weight gain of 13 kg.[7] It is the case, however, that this is the mean of a very wide range of weight gains also associated with satisfactory outcomes of pregnancy.

The explanation for this and the reason why advice about energy consumption is so difficult comes from the studies of Prentice and colleagues both in the Gambia and in the Dunn Nutrition Unit in Cambridge,[8] where they have shown with calorimetry studies that women vary dramatically in both basal metabolic rate and total energy expenditure from the nonpregnant to the pregnant state. Indeed, women can be categorised into energy profligate or energy sparing during pregnancy with the energy profligate requiring on average an additional 80 000 kcal to meet the increased energy expenditure of pregnancy, whereas the energy sparing group will get through pregnancy with a net reduction in expenditure of approximately 13 000 kcal, principally because of a significant fall in basal metabolic rate in the first two trimesters. This fall may well be associated with a drop in the core temperature and may vary with the seasons and the ambient temperature. It does mean, however, that in the absence of more accessible testing of energy expenditure which could be applied widely, it is impossible to advise individual women about their energy intake other than to say 'eat to appetite'.

Studies looking at energy intake based on dietary recalls, such as those of Durnin and colleagues in Glasgow, have reported no significant change in dietary intakes with advancing pregnancy.[9]

A summary of UK recommendations of energy and nutrient intakes for healthy women aged 19–50 years and the modest increments proposed in pregnancy are summarised in Table 1. The proportions of energy

Table 1. Dietary reference values for women in the UK

Nutrient/day	Women (19–50 years)	Pregnancy
Energy (kcal)	1940	+200[a]
Protein (g)	45	+6
Thiamin (mg)	0.8	+0.1[a]
Riboflavin (mg)	1.1	+0.3
Niacin (mg)	13	[b]
Vitamin B6 (mg)	1.2	[b]
Vitamin B12 (g)	1.5	[b]
Folate (μg)	200	+100
Vitamin C (mg)	40	+10
Vitamin A (μg)	600	+100
Vitamin D (μg)	–	10[c]
Calcium (mg)	700	[b]
Phosphorus (mg)	550	[b]
Magnesium (mg)	270	[b]
Sodium (mg)	1600	[b]
Potassium (mg)	3500	[b]
Chloride (mg)	2500	[b]
Iron (mg)	14.8	[b]
Zinc (mg)	7.0	[b]
Copper (mg)	1.2	[b]
Selenium (μg)	60	[b]
Iodine (μg)	140	[b]

[a] Third trimester only

[b] No increment

[c] A 10μg supplement is required as this level is not usually achievable through diet. It is especially important for those most at risk of deficiency:[6]

- women of South Asian, African, Caribbean or Middle Eastern family origin
- women who have limited exposure to sunlight, such as women who are predominantly housebound or usually remain covered when outdoors
- women who eat a diet particularly low in vitamin D, such as women who consume no oily fish, eggs, meat, vitamin D-fortified margarine or breakfast cereal
- women with a prepregnancy body mass index above 30 kg/m^2

derived from fat (35%) and carbohydrate (50%) remain the same in pregnancy as for the nonpregnant woman (Table 1).[10]

5. Healthy eating in pregnancy

General advice about healthy eating, such as *Eating while you are pregnant* from the Food Standards Agency, can be recommended to pregnant women.[11] Five food groups are referred to with simple advice (Table 2). The Food Standards Agency (FSA) 'eatwell plate' can also be recommended to pregnant women, with some minor changes that are outlined below.[12]

Healthy eating in pregnancy should exclude food sources which might contain teratogens, such as supplements and foods containing high concentrations of pre-formed vitamin A (retinol), such as liver and liver products, or be the source of food-borne illness such as listeriosis (mould-ripened soft cheeses, unpasteurised milk or pates) or toxoplasmosis (undercooked meat or salad vegetables contaminated with soil). Caffeine consumption should be restricted to under 200 mg/day (roughly two mugs of instant coffee) as high caffeine intakes have been associated with small-for-gestational-age babies and miscarriage. Peanut avoidance is now not recommended unless the mother herself is allergic to peanuts.

Table 2. The five food groups

Food group	Advice
Bread, other cereals and potatoes	Eat plenty, choosing wholegrain varieties if possible.
Fruit and vegetables	Eat a variety – at least five portions/day. Remember that potatoes do not count and pure fruit juice can only count once towards the five a day.
Milk and dairy foods	Eat or drink moderate amounts and choose low-fat versions whenever you can.
Meat, fish and alternatives (such as beans, lentils, eggs, soya products)	Eat moderate amounts and choose lower fat meat products whenever you can.
Foods and drinks containing high amounts of fat and/or sugar	Eat foods containing high amounts of fat sparingly and look out for the low-fat alternatives. Foods and drinks containing sugar should not be eaten too often as they can contribute to tooth decay.

Table 3. Diabetes UK nutritional advice to people with diabetes (modified from Food Standards Agency)[15]

Dietary component	Dietary recommendation for people with diabetes
Protein	Not >1g/kg body weight
Total fat	<35% of energy intake
Saturated + transunsaturated fat	<10% of energy intake
n-6 polunsaturated fat	<10% of energy intake
n-3 polyunsaturated fat	Eat fish, especially oily fish, once or twice weekly
Fish oil supplements not recommended	
Cis-monounsaturated fat	10–20% of energy intake
Total cabohydrate	45–60%
Sucrose	Up to 10% of daily energy
Fibre	No quantitative recommendation Soluble fibre – has beneficial effects on glycaemic and lipid metabolism 'Insoluble' fibre – no direct effects on glycaemic and lipid metabolism but its high satiety content may benefit those trying to lose weight and it is advantageous to gastrointestinal health
Vitamins and anti-oxidants	Encourage foods naturally rich in vitamins and antioxidants
Salt	≤ 6 g sodium chloride/day

A current dilemma in nutritional advice, concerns the position of oily fish – an important source of omega 3 fatty acids but also potentially contaminated with methyl mercury and polychlorinated biphenyls, which can be harmful to fetal development. Current FSA advice is to consume two portions of fish a week, one of which should be oily. No more than two portions of oily fish should be consumed. Pregnant women should also avoid eating shark, swordfish and marlin and should limit the amount of tuna consumed to no more than two steaks a week or four medium-sized cans a week.

6. Dieting in pregnancy

A commonly expressed concern (with regard to fetal development), particularly when obesity complicates pregnancy, is the safety of calorie-restricted and other weight-losing diets. There is little evidence of harm in the first half of pregnancy – but in the second half concerns arise, because calorie restriction will lead to lipolysis and relative ketonaemia, which has an inverse relationship to mental-development index scores.[13]

The relative ketonaemia of late pregnancy, demonstrated by beta-hydroxybutyrate levels, is prevented by the adoption of a high carbohydrate, low glycaemic index diet.[14] Since the lipolysis is suppressed by the enhanced insulin sensitivity induced by the dietary pattern, such a diet may be safely recommended to pregnant women who are overweight and obese, with the advantage that it may also prevent the onset of gestational diabetes. The current Diabetes UK advice is suitable and is summarised in Table 3.[15]

Specific advice on the prevention of excessive weight gain in pregnancy is the subject of a current review by National Institute for Health and Clinical Excellence. The Centre for Maternal and Child Enquiries and the RCOG have also released a joint guideline that provides standards of care for the management of women with obesity in pregnancy.[16]

7. Nutrient supplementation in maternal undernourishment

Many experiments have been performed in the developing world where protein/calorie malnutrition may prejudice the outcome of pregnancy and in the developed world in selected population groups at nutritional risk because of poor living conditions and/or low income. Most of these studies are of

historical interest and have been reviewed in detail by Rush.[17] In summary, carbohydrate-rich supplements had surprisingly modest effects on increasing birth weight (less than 100 g in all but one study). Of concern was that high protein supplements (when protein content of the supplement exceeded 20% of total energy) were associated with a reduction in mean birth weight.

8. Healthy Start

Among women with a low income in the UK where nutrition might be prejudiced by the inability to purchase adequate amounts of food, the newly introduced Government Healthy Start benefit appears to be effective. In a recently published study, recipients of Healthy Start compared with similar women with a low income on the earlier Welfare Food Scheme have enhanced intakes of energy, calcium, iron and folate. Their dietary patterns are also modified by a relative increase in the daily portions of fruit and vegetables.[18] The possible ramifications of this on public health and child development in the UK await evaluation as the programme becomes established.

9. Opinion

Human reproduction is successful through a wide range of nutritional exposures and despite considerable variation in body mass index. There are obviously major physiological differences between individuals with regard to energy requirements in pregnancy but in populations such as that in the UK there appears to be a threshold of approximately 1600 kcal/day above which there is no significant compromise of fetal growth or development. Specific nutrient deficiencies are recognised more commonly in the developing world where iron deficiency and iodine deficiency may contribute to adverse pregnancy outcomes and, in the UK, iron, folate and vitamin D deficiency are relatively common in some groups.

10. Nutritional advice to women prepregnancy, in pregnancy and during lactation

Many sources of information are available to the public and of variable quality but the following leaflets and websites can be recommended:

- Food Standards Agency: www.food.gov.uk/aboutus/publications/nutritionpublications/
- *Healthy Eating Before, During and After Pregnancy*, University of Sheffield, Centre for Pregnancy Nutrition, order via www.eatingforpregnancy.org.uk.

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This Scientific Impact Paper was produced on behalf of the Royal College of Obstetricians and Gynaecologists by:
Dr NR Vulliemoz, Institute of Reproductive Sciences, Oxford, Mr E McVeigh FRCOG, Oxford and Dr J Kurinczuk MD MSc FFPH, National Perinatal Epidemiology Unit, Oxford

and peer-reviewed by:
Mr PRS Brinsden FRCOG, President, British Fertility Society; Professor T Fleming, Professor of Developmental Biology Southampton; Professor AH Balen FRCOG, Leeds; Professor MD Kilby FRCOG, President, BMFMS.

The Scientific Advisory Committee lead reviewer was:
Professor SM Nelson MRCOG, Glasgow.

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The review process will commence in 2013 unless otherwise indicated.

CORRIGENDUM

This document was originally published in April 2010.
Table 1 was subsequently found to contain errors, which have now been corrected.

