REVIEW ARTICLE

Maternal obesity: a review of interventions

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SUMMARY

Background: Obesity has become a serious global public health issue and has consequences for nearly all areas of medicine. Within obstetrics, obesity not only has direct implications for the health of a pregnancy but also impacts on the weight of the child in infancy and beyond. As such, maternal weight may influence the prevalence and severity of obesity in future generations. Pregnancy has been identified as a key time to target a weight control or weight loss strategy to help curb the rapidly growing obesity epidemic. In addition, if delivered sensitively, pregnancy may be a good time to target health behaviour changes by using the extra motivation women tend to have at this time to maximise the health of their child. Aim: This study reviews the current evidence for interventions to promote weight control or weight loss in women around the time of pregnancy. A comprehensive review of medical research – PubMed, Embase, Ovid Medline and the Cochrane Clinical Trials register – showed that despite numerous reports of the prevalence and complications of maternal obesity, few intervention strategies have been suggested. Conclusion: This study finds that there is a deficiency of appropriately designed interventions for maternal obesity and it concludes by highlighting areas for developing a more effective strategy.

Global epidemic

Both the developed world and developing countries are experiencing a rapid increase in the prevalence of obesity. Globally, a 50% increase was reported from 1995 to the year 2000 and current estimates from the International Obesity Task Force (1) suggest that today, over 300 million adults are obese and a further 1 billion are overweight. The most recent data in the UK from the Health Survey for England (2006) (2) show that nearly a quarter of both men (23.6%) and women (23.8%) were obese. These dramatic figures are projected to rise even further over the coming decade. In acknowledgement of this trend, described by the World Health Organisation as one of the biggest public health challenges of the 21st century, the British government requested a review of the problem for future management. This report, compiled by Foresight, a science-based think tank, forecast levels of obesity by 2050 to be 60% of men and 50% of women. On a financial scale, this burden is estimated to cost an extra £45.5 billion per year in obesity-related health funding.

A key component of this dramatic increase is the cycle of obese parents producing offspring with a tendency for childhood obesity, who then become obese parents themselves thereby perpetuating the problem. Currently one-fifth of the obstetric population in the UK is obese (3). If ignored, the children born to these mothers have an increased risk of obesity themselves because of developmental programming and over-nutrition in utero as well as environmental exposure to the same obesinogenic lifestyle as the mother. As identified by the Foresight report, an essential part of any strategy to curb this trend is a long-term prevention programme targeted at the family unit.

Definition

Obesity is defined as ‘an accumulation of excess body fat, to an extent that may impair health’. The most basic indicator, mean body mass index (BMI, kg/m²), is the accepted measure of the WHO and the Institute of Medicine (IOM); this categorises weight profiles into the following:

- BMI < 18.5 kg/m²: Underweight
- BMI, 18.5–24.9 kg/m²: Normal
- BMI, 25–29.9 kg/m²: Overweight
- BMI ≥ 30 kg/m²: Obese
Central obesity, which is defined as waist circumference \( \geq 94 \) cm for Europid men and \( \geq 80 \) cm for Europid women, with ethnicity-specific values for other groups (according to new IDF definition) (4) as opposed to peripheral distribution of fat is associated with worse outcomes.

**Pregnancy**

Pregnancy is a crucial life event when interventions to challenge the growing trend of obesity may be most effective. The mother may be more than usually accepting of change that would benefit the health of her unborn child. The benefits of weight management in pregnancy are numerous. Normal pregnancy has been implicated in the development of obesity in women having healthy weight previously (5).

Controlling weight at this time is not only important to prevent future complications of obesity for the woman herself, but also to improve the health of the pregnancy, and the neonate. Numerous adverse effects of obesity during pregnancy have been reported by many. Associations include an increased risk of miscarriage, congenital malformations, hypertension, gestational diabetes, pre-eclampsia, anaesthetic complications, vaginal birth after caesarian (VBAC) failure, instrumental delivery, macrosomia and maternal death (6). Controlling weight in association with pregnancy will therefore impact many areas of adult, obstetric and neonatal healthcare.

**Impact on NHS services**

The health complications of obesity in pregnancy create a significant burden on the personnel and finances of the NHS. It has been estimated that obese mothers spend on average 4.83 more days in hospital than those of normal weight and their care costs are fivefold higher. The cost of caring for their infants is also higher as there is a 3.5-fold increase in the possibility of requiring admission to neonatal intensive care unit (NICU) (7).

It is generally understood that obese women and their children may require additional care but often, provisions are not readily available. One study qualitatively assessed the impact of maternal obesity on the NHS services in the North East (8). Thirty-three healthcare professionals were interviewed including members of the midwifery team, obstetricians and dieticians. This study emphasised the emotional and psychological aspects of caring for obese women during pregnancy highlighting frustration in many centres that national directives to promote awareness about weight control rarely included information on reproductive issues. Overweight- and obese women are not receiving education about pregnancy-related issues on a national level, leaving the responsibility with the local healthcare professionals. The challenge of counselling obese women individually before they conceive is an almost impossible task with the current rate of unplanned pregnancies. Further, without clear guidelines to direct care, discussing the sensitive issue of weight and body image are significant barriers to optimal care.

**Current research**

A comprehensive investigation of medical databases including PubMed, Embase, Ovid Medline and the Cochrane Clinical Trials register produced very little data on interventions relating pregnancy, obesity and health risks. Despite a plethora of articles and reviews reporting the prevalence and implications of maternal obesity on the health of mother and infant, surprisingly very few intervention options have been suggested, let alone undertaking clinical trials, in an attempt to combat this burgeoning problem.

The audience present at a meeting of the 53rd Study Group of the Royal College of Obstetricians and Gynaecologists focussing on obesity and reproduction identified this critical deficiency. Although the panel provided new insight into the depth and breadth of the problem of obese women in reproductive medicine, the analysis highlighted a lack of evidence from which to draw conclusions and direction from which to build recommendations.

The purpose of this article is to review the current evidence for interventions to promote weight control or weight loss in women around the time of pregnancy. To approach this systematically, the literature may be divided according to the time period in the reproductive phase targeted by the trial. When assessing an intervention to assist weight loss to improve the health of a pregnant woman, the timing must be a compromise between that which will be of the most absolute benefit to mother and child, and that which is practically acceptable to encourage adherence. Studies have shown positive correlations between both maternal prepregnancy weight (9) and gestational weight gain (10) with the birth weight of the infant and associated health risks, so interventions have been put to clinical trials at both time points. In addition, the postpartum period has been targeted to reduce the increased metabolic risks for the mother retaining weight gained during pregnancy and better prepare the women physiologically for a subsequent pregnancy. The second part of the balancing act has proven more difficult to achieve and may be the determining factor in any successful intervention.
Maternal obesity

Prepregnancy interventions

High-risk women
Targeting overweight and obese women before they become pregnant would perhaps be the most effective solution but almost impossible to implement. There are no known trials aimed at overweight or obese women who are planning to conceive that have not already contacted medical services for assistance in fertility. Therefore, this section includes studies which address issues in addition to obesity and pregnancy. This is an attempt to fill some gaps in the evidence from medical literature, which may be relevant to interventions for obstetric obesity.

Many pregnancies are unplanned and increasingly younger women are becoming pregnant. Therefore, it would be difficult to define a target population which included all at-risk women. Additionally, even in the case of planned pregnancy, very few women would consult a health professional before conceiving and fewer still are likely to then agree to postponing their family planning for a number of months or years in order to lose weight if so advised.

A comparable trial in design but not in objective is the Swedish Health Hunters Trial conducted in 2006 (11). This study recruited women between the ages of 18 and 28 years who had at least one severely obese parent, placing the women at high risk of developing obesity themselves. These women were randomised into a control or an intervention group. Those in the intervention group received individualised programmes for diet, weight control and physical activity and were supported throughout the study with email, telephone and group booster sessions. Although small, after 1 year, this study showed significant differences in body weight between the two groups of women.

Unfortunately, this trial used pregnancy as criterion for exclusion. Data from six of the 30 participants who became pregnant during the trial were removed from analysis and the outcomes of the pregnancies were not recorded. However, the results of this study, in the short term at least, support the use of a customised strategy, accompanied by peer group sessions in effective weight management for young women at high risk of developing obesity. Perhaps a similar intervention could be offered to young obese women or those with risk factors for obesity as a preventative measure for future maternal obesity. Provided weight remains above the lowest healthy measure for the woman’s age and height, she can only benefit from such a healthy lifestyle intervention whether she becomes pregnant or not.

Sub-fertility

Compared with normal weight women, fertility in obese women is lower for both natural conception (12) and assisted reproduction (13). One study demonstrated that the chance of becoming pregnant per cycle of insemination treatment decreased with increasing waist-to-hip ratio and many have shown that in vitro fertilisation (IVF) is less successful in overweight and obese women. This relationship between obesity and sub-fertility may be explained in part by a reduction in the frequency of ovulation. A common cause of reduced frequency of ovulation or anovulation is polycystic ovarian syndrome (PCOS), a condition associated with obesity particularly with central adiposity. Central visceral obesity is present in more than 40% of patients with PCOS (14), which is related to elevated androgen levels, hyperinsulinaemia or leptin (15,16). They have lower serum high-density lipoprotein cholesterol (HDL-C) or HDL2-C concentrations, as well as higher triglyceride and low-density lipoprotein concentrations than age- and weight-matched control women (17,18).

There is an increased incidence of hypertension, coronary heart disease and thrombosis in women with PCOS. This has been attributed to elevated plasminogen activator inhibitor levels (19,20) together with alteration in serum lipids.

In general, both obese and non-obese PCOS patients tend to be insulin-resistant (21). Although oestrogens are known to enhance insulin sensitivity, elevated androgens, specifically dihydrotestosterone and testosterone exacerbate insulin-resistance (22–24), possibly accounting for some of the insulin-resistance seen in obese people and people with PCOS. Hence, a high-fibre, low-glycaemic-index diet with adequate protein and monounsaturated fatty acids is recommended (25). Weight loss has been associated with a significant decrease in serum insulin concentration following a 6-month intervention (26,27). Exercise has also been shown to have a positive effect on PCOS not only in weight loss but also in reducing serum testosterone concentration (28). The recent advances in bariatric surgery like gastric banding have also been used in morbidly obese patients with PCOS. Results from trials in Canada and Spain have shown a marked improvement in hirsutism, restoration of regular menstruation and spontaneous conception (29,30).

In 1995, a pilot trial was implemented in Sydney, Australia to assess the effectiveness of weight loss in anovulatory obese women to help establish ovulation and assist in conception (27). Eighteen obese (BMI ≥ 30 kg/m²) women who had failed to conceive for over 2 years and who were not ovulating,
were recruited into a 6-month programme, away from the conventional fertility treatment environment. Each week, the women participated in a 2-h group session. The first hour provided an opportunity for the women to take part in aerobic exercise together and they were further encouraged to do at least two additional aerobic exercise sessions per week. The second hour consisted of seminars and discussions on diet and physical activity, allowing time for peer problem-solving and experience-sharing. Importantly, all discussions about fertility were disallowed from these sessions to shift the focus of the group from fertility issues to healthy living. There was an average weight loss of 6.3 kg amongst those who completed the study and no significant weight change in those who did not. Of the 13 women to complete the study, 12 began ovulating within 6 months and 11 became pregnant by 12 months after the end of the intervention. A second cohort of 12 women, who refused to participate in the trial, was concurrently followed through the usual treatment channels and only one had conceived by 12 months after the study.

The success of this intervention led to a larger trial 3 years later, which reported even greater efficacy (26). In this case, the average weight loss was 10.2 kg. Fifty-two out of 60 participants were pregnant by 12 months following the start of the study and a much lower miscarriage rate of 18% was observed compared with 75% previously observed during fertility treatment for the same group of women. Financially, this trial also proved the intervention to be more cost-effective than conventional treatment alone. Prior to the intervention, the average cost per live birth was estimated at AUS$275,000 and after the intervention, the cost of care for each live birth was reduced to AUS$4600.

The authors of the study cite psychological factors as an important contributor to the outcome. Psychologists involved in the intervention helped to shift the women’s focus from trying to get pregnant to that of leading a healthy lifestyle. It is likely a change in attitude from the negative emphasis of not being able to conceive to a positive outlook helped the women to release some emotional stress and redirect their energy, providing them with the motivation they needed to lose weight and improve their chances of conception. It is important to note that most of the women who achieved weight loss and pregnancy throughout these studies remained in the overweight or obese BMI categories. This indicates that physiologically, success may be because of a change in fat distribution and/or endocrine factors rather than absolute weight reduction itself. In addition, not all cases of sub-fertility in obese women can be attributed to anovulation, as delayed conception has also been noted in ovulating obese women (31). Weight loss is now included in the initial advise for women with a BMI > 29 kg/m² experiencing delayed conception. National Institute of Clinical Excellence (NICE) guidelines recommend informing women to join a group programme involving exercise rather than diet alone; however, there are no national public schemes available to assist women in this. Fertility treatment may be restricted based on BMI depending on the clinic and whether it is a private or publicly funded centre but generally, it is not advisable to undergo fertility treatment with a BMI > 30 kg/m². Further research is required to investigate the link between sub-fertility and obesity in young women who do not have other metabolic conditions to understand more closely the physiological role of excess fat and help direct lifestyle management and medical treatment.

**Bariatric surgery**

An increasingly popular option for weight loss in the morbidly obese (BMI ≥ 40 kg/m²) is surgery. A variety of procedures are available, some restrictive and others malabsorptive, all of which have implications for the health of both mother and foetus during a pregnancy. One study attempted to evaluate the safety of pregnancy following laparoscopic adjustable gastric banding (LAGB). This group contacted women who had had successful pregnancies from hospital records, therefore disregarding a substantial population of women who have had LAGB and subsequent miscarriage or stillbirths. However, in women who had a live birth with a LAGB, in relation to complications during pregnancies before the LAGB procedure, the incidence of gestational diabetes was reduced by 19% and hypertension by 14.5%. Mean gestational weight gain was reported to be 3.7 kg with the LAGB compared with a previous 15.6 kg, which is undoubtedly a significant factor in the reduced rates of metabolic complications (32).

Another paper reported the outcome for children born to women following bili-pancreatic duodenal bypass surgery, the procedure reported to have the most potential for foetal malnutrition. The intervention reduced the average BMI of 113 women from 48 to 31 kg/m² and the rate of caesarean section needed for primiparas was almost halved. The group compared same age siblings born before and after the surgery to compare the prevalence of obesity. In young children, a reduction was found in overweight or obese offspring from 60% to 35% and in adolescents, a similar pattern was observed, with a greater reduction seen in boys than girls (33).
Interventions during pregnancy

It is generally accepted that women should not attempt to lose weight during pregnancy. Therefore, interventions during pregnancy aim to limit weight gain throughout gestation, a factor, which has strong correlations with long-term health risks associated with obesity for both the mother and the child. There are no official British guidelines for weight gain during pregnancy and the literature commonly uses recommendations from the American IOM guidelines. The limits of weight gain are divided into BMI categories as follows:

| BMI Category | BMI Range (kg/m²) | Weight Gain Limit (lb) |
|--------------|------------------|------------------------|
| Underweight  | BMI < 19.9        | 28–40                  |
| Normal weight| 19.9–26.1        | 25–35                  |
| Overweight   | 26.1–29.9        | 15–25                  |
| Obese        | BMI > 29.0        | 13–15                  |

Originally designed in 1990 to reduce the incidence of low birth weight infants, they are now considered by many to be too liberal to appropriately assist in the challenges facing today’s antenatal population and are currently under revision (34).

An American National and Maternal Health Survey showed that women, who gain more weight during gestation than the amount recommended by the IOM, retain more than twice that of women who remain within the guidelines throughout their pregnancy (35). This retrospective study was carried out on women who gave birth before the introduction of the IOM guidelines and also showed a difference in retention between white and black women. White women who gained above the IOM recommendations retained 2.2 kg at 10–18 months postpartum compared with 0.7 kg retained by those who stayed within the guidelines. African American women who exceeded the IOM recommendations retained 5.8 kg compared with 3.3 kg in those who gained within limits. This may indicate a need for targeted interventions according to ethnicity as needs may vary, and will be discussed below in more detail.

Another study followed over 1000 normal weight women through two consecutive pregnancies and found that gaining over the recommended amount of weight during the first pregnancy resulted in a threefold increased risk of being overweight at the time of the second pregnancy (36). Therefore, despite a normal prepregnancy weight, those with a high gestational weight gain are still at risk of higher postpartum weight retention, higher levels of subcutaneous fat deposition and higher infant birth weight (37). All of these outcomes increase the risk of encountering metabolic and physical problems associated with obesity in later life.

Trials seeking to intervene in gestational weight gain are growing in importance as the prevalence of excessive gestational weight gain is increasing (38). As a greater proportion of women exceed the IOM recommendations, more and more are exposed to the risks of obesity-related health problems. The role of diet and physical activity in this trend of excess gestational weight gain is still unclear (39). As discussed below, even successful trials have not been able to identify clear contributors to the success.

The earliest trial that reported an intervention to limit weight gain during pregnancy was conducted in four communities of the indigenous population of Quebec, Canada. Concern was raised within this antenatal population because of a particularly high (12.8%) prevalence of gestational diabetes mellitus (GDM) and the aims of this study were to avoid gestational diabetes, infant macrosomia and postpartum weight retention through reduction of gestational weight gain (40).

The first 8 months of the trial were used as a control period and the intervention was implemented during the following 10 months. Two nutritionists lived and worked with health workers of the Cree communities to deliver an integrated programme to all pregnant women attending antenatal clinics during the time of the intervention period. Each woman was counselled by a nutritionist at least monthly and in addition, the study team delivered local radio broadcasts and pamphlets advising healthy eating and exercise in pregnancy, organised supermarket tours and cooking demonstrations and group walking sessions.

Average weight gain remained high at around 0.5 kg per week and no significant differences were seen between the amount gained in the control and intervention groups. Many of the women participating were overweight and were found to gain more than the normal weight women. In both groups, average energy intake for overweight women (142 kJ/kg) remained above the recommended amount (105 kJ/kg), the level of physical activity was low and no difference was found in infant birth weight between the two groups.

The number of women with a high result in a glucose challenge test (GCT) did not differ between the groups. Interestingly, those diagnosed with GDM continued on the same weight trajectory as those with a normal GCT, whereas a more common observation is the slowed or halted weight gain following diagnosis because of strict diet and/or medical treatment. This may be an indication of cultural influences on weight control during pregnancy, supported
by the Cree elders who said that ‘plumpness’ is desirable and weight gain during pregnancy is encouraged and regarded as healthy.

The intervention group reported a much lower level of activity than the control group and it is suggested this may be because the intervention group were constantly being reminded to exercise and so evaluated their energy output differently to those in the control group.

A Swedish study (41) compared the weight gain in pregnant women; keeping 7 kg as a benchmark. Women were randomly assigned to an index (155) and control (130) group respectively. An intervention programme with weekly motivational talks and aqua aerobic classes was offered to women in the index group. Weight gain in kilograms, delivery and neonatal outcome were studied.

The index group had a significantly lower weight gain during pregnancy compared with the control group. They also weighed less at the postnatal check-up compared with the weight registered in early pregnancy. The percentage of women who gained more than 7 kg was greater in the control group. In addition, the women in the index group had a significantly lower BMI at the postnatal check-up, compared with the control group. Interestingly, there were no differences between the index group and the control group regarding birth weight, gestational age and mode of delivery. The intervention programme was effective in controlling weight gain during pregnancy and did not affect delivery or neonatal outcome.

Another, little known trial conducted a computer-assisted self-interview intervention amongst a small cohort of pregnant adolescent African American girls. Again, this was a targeted study as statistics at the time showed 47% of African American women were obese compared with just 23% in the white population. Prevalence of obesity-related disorders such as diabetes and hypertension were similarly disproportionate (42).

A sample of 46 pregnant girls between the age of 13 and 18 were recruited and randomised into a control or intervention group and participated in the study from first trimester of pregnancy through to 6 weeks postpartum. The intervention group received three 20-min talks promoting a healthy diet and physical activity focusing specifically on the appropriate stage of pregnancy aiming for a developmental approach. For example, the first session held at the beginning of the second trimester dealt with nutritional issues surrounding nausea and vomiting. The control group received standard advice from their health worker.

The intervention group gained significantly less weight during the first trimester and retained less at 6 weeks postpartum. Conversely, the intervention group was found to gain significantly more weight during the third trimester so the results were not consistent throughout pregnancy. Interviews showed that the intervention group had decreased their daily calorie intake and the percentage fat content of their diet was comparable with controls. This was reported as a significant outcome of the intervention as young women were often indulging in high fat, high calorie diets, which encouraged the development of obesity and its related health problems. Although, women should not restrict their calorie intake particularly younger pregnant women who are still developing, the content of the diet is an area which should be targeted for a healthier pregnancy and ongoing lifestyle.

It may be possible to identify high risk women early in their pregnancy as weight gained during the first 20 weeks of pregnancy was shown to be a good indicator of overall weight gain (43). This is an important consideration for more effective and efficient interventions in the future.

In 2002, Polley et al. (44) recruited 120 women into a randomised control trial, which used the IOM guidelines to direct an intervention to control gestational weight gain. The women were randomised to a control or intervention group and then subgrouped into normal (BMI, 19.8–26 kg/m²) or overweight (BMI > 26 kg/m²).

A stepped care approach was delivered to the intervention group. At the first of regular visits to the antenatal clinic, the IOM guidelines were explained, advice on exercise and healthy eating in pregnancy was given and a personal weight gain by BMI chart was drawn up for each woman to track their progress. If the woman remained within the IOM limits, she was encouraged to continue whereas if she exceeded the limits on four consecutive visits, a more intense approach was adopted to include goal setting and meal planning with follow up telephone calls.

The percentages of normal weight women exceeding the IOM guidelines by the end of the pregnancy was 58% in the control group and 32% in the intervention group. For overweight women, this pattern was reversed with 33% exceeding the IOM guidelines in the control group and 59% in the intervention group (see Figure 1). In addition, normal weight women in the control group were more likely to exceed the IOM guideline at any point during the pregnancy compared with normal weight women in the intervention group. However, for overweight women, two-thirds of both the control and intervention groups exceeded the IOM recommendations at least once during their pregnancy.
Although a reduced fat consumption and increased energy expenditure was reported in the intervention group compared with controls, neither correlated with the proportion of women exceeding the IOM guidelines highlighting the inaccuracies of self-reporting.

This intervention may have been counterproductive for overweight women because they may have already been struggling to control their weight and focusing on it further may have caused dis-inhibition and overeating. If this is a factor, an intervention which increases the pressure following failure may not be appropriate for overweight women. The sample used for this trial was small and concentrated in a low socio-economic area with low education levels. Therefore, it is possible that lack of knowledge and additional social problems encountered by these women may have prevented them from prioritising gestational weight control and effectively using the intervention tools. A more diverse sample of women may have yielded different results and be of more relevance for the general population.

Also, waiting for four consecutive visits with an excessive gestational weight gain may have let the problem run for too long for effective behavioural change to be implemented.

A trial by correspondence was shown to be effective for overweight women with a low income. Using 359 historical controls, 158 women were followed from early pregnancy to 1 year postpartum during which time they were delivered a postal based intervention to educate them on weight control according to the IOM guidelines, healthy eating, exercise and self-monitoring using colour-coded BMI charts. In addition, a postcard accompanied each newsletter to be returned with any questions the women may have and goals they had set for themselves. Engagement in the trial was measured by the rate of return of the postcards. 84% returned at least one postcard and 36% returned all five (45).

The principal outcome was the proportion of women who exceeded the IOM guidelines during their pregnancy and the proportion of women retaining more than 5 lb (2.27 kg) at 1 year postpartum. The results are illustrated in Figures 2 and 3.

Overall, the proportion gaining more than the IOM guidelines did not differ between the control (41%) and intervention (45%) groups. However, significant differences were found when the data was divided and analysed according to income status. Those in the low-income group were less likely to exceed the IOM guidelines in the intervention group (33%) compared with controls (52%), regardless of their prepregnancy weight. At 1 year postpartum, the intervention was found to be significantly effective for low-income overweight women and high-income normal weight women.

The positive results of this trial for women in a low-income group should have some influence on the way such women are targeted in future interventions. Polley et al. did not find any significance of their intervention on low-income group women so the mode of delivery of an intervention is likely to be important for this group where access to health services may be a particular barrier (46).

This trial was designed to minimise clinical time expenditure, cost and interruption other service provision. Given this and the favourable results, perhaps a randomised control trial using a similar intervention should be considered to better represent the outcome within the general population.

The most recent completed trial was conducted in the primary care setting in Finland. A group enrolled six maternity clinics, three as controls and three as intervention providers, to evaluate the impact of individual counselling on weight gain during pregnancy. During five routine antenatal visits between 8 and 37 weeks gestation, a public health nurse gave information about the IOM guidelines along with individual advice on a healthy diet and optimal physical activity (47).

The dietary advice focused on the following four themes:

• Having a regular meal pattern, including breakfast.
• Eating five portions of fruit, vegetables or berries per day.
• Eating mostly high fibre bread.
• Restricting intake of high sugar snacks to one per day.

The physical activity was measured in units called metabolic equivalents. The target for a week was 800 units with each minute of moderate exercise counting for 5 units and each minute of intense exercise counting for 7 units. Both diet and physical

![Figure 1](https://example.com/figure1.png)  
**Figure 1** Percentage of women whose total weight gain exceeded Institute of Medicine (IOM) guidelines
activity was self-recorded in a weekly diary which was checked and commented on by the public health nurses at each visit.

The results of the trial showed a non-significant trend for women in the intervention group to exceed the IOM recommendations more often than those in the control group. The dietary component of the intervention did achieve a significantly higher intake of fruit, vegetables and berries but no difference was seen in the exercise logs. Of the infants born to the control group, eight were of high birth weight compared with none in the intervention group. Although statistically significant, this was explained by mothers of the high birth weight infants often being taller with a greater gestational weight gain and a longer gestation than other women across the groups.

One factor that may have affected the results was the greater proportion of smokers in the intervention group. All smokers in both groups either quit or cut down during their pregnancy and this could have been a factor causing weight gain despite the efforts of the intervention.

Finally, the New Life(Style) Study (48) has recently been completed in the Netherlands. Their intervention aimed to keep gestational weight gain within the IOM limits for primigravida women through individual counselling sessions focussing on explanation of the IOM guidelines, nutrition and exercise, reviewing individual lifestyle and providing individual support. They aimed to enrol 275 women into the trial to be randomised between usual and interventional care groups. The intervention would be delivered at five counselling sessions, the last being at 6 weeks postpartum and the women followed up to 1 year postpartum. They planned to measure the outcomes of weight, BMI, skin-fold thickness, nutrition, exercise and blood levels of various hormones.

The authors chose to include only primigravida women in this study to exclude previous experience and expectations of weight change during and after pregnancy. This is a factor, which is likely to influence the behaviour of a woman during pregnancy and the adherence to advice or a prescription of diet and exercise patterns.

Low-carbohydrate/high-protein diets such as Atkins have recently become popular for weight control. Such diets have been associated with an increased risk of kidney problems and metabolic ketoacidosis, another potential prenatal stressor. Beta-hydroxybutyrate which is one of the by-products of ketoacidosis has been linked to stunted behavioural and intellectual development in offspring (49). Studies conducted on 55,000 pregnant women way back in 1974 (Maryland State Medical Journal 1974: 70.) have linked ketoacidosis to 'significant neurological impairment' and an average loss of about 10 IQ points. The current recommendations by Atkins suggest using the diet with caution in pregnancy, under strict medical supervision. Other weight loss programmes like weight watchers do not include data and recommendations for pregnant women although there is a lot of emphasis on prepregnancy weight control.

Khoury et al. (50) conducted a study to assess effect of low carbohydrate diet on utero-placental circulation. Two hundred and ninety non-smoking white women, aged 21–38 years, without previous pregnancy complications and carrying a single foetus were assigned randomly to continue their usual diet (control subjects; \( n = 149 \)) or to adopt a low-cholesterol low-saturated fat diet (intervention group; \( n = 141 \)) from gestational week 17–20 to birth. Doppler velocimetry of the umbilical artery and both uterine arteries were assessed at gestational weeks 24, 30 and 36. Physiologic gestational decrease in umbilical artery pulsatility index (PI) from weeks 24 to 30 was more pronounced in the intervention group.
The change in umbilical artery PI and mean PI value of the uterine arteries between weeks 24 and 36 were not significantly different between the two groups. It has been concluded that a cholesterol-lowering diet during pregnancy may modify foeto-placental circulation in mid-pregnancy.

Reynolds et al. (51) from Queens research centre, Edinburgh measured salivary cortisol concentrations during a modified Trier Social Stress Test in 70 men and women aged 36.3 years whose mothers had taken part in a dietary intervention in which they were advised to eat 1 pound (0.45 kg) of red meat daily during pregnancy and to avoid carbohydrate-rich foods. The offspring of women who reported greater consumption of meat and fish in the second half of pregnancy had higher cortisol concentrations during the Trier Test. Compared with the offspring of mothers who had reported eating no more than 13 meat/fish portions per week, the average cortisol concentrations were raised by 22% (95% confidence interval, 13–71%) and 46% (5–103%) in the offspring of those eating 14–16 and at least 17 portions per week respectively. These findings provide the first human evidence that an unbalanced high protein maternal diet during late pregnancy leads to increased cortisol secretion in response to psychological stress in the offspring.

A study conducted by school of nursing in Manchester looked at influence of behaviour patterns on weight loss (52). According to the theory of planned behaviour (TPB), the human behaviour is influenced by beliefs. Identification of people’s beliefs is an essential step in the design of behaviour-change interventions. A qualitative approach was employed using semi-structured interviews to interview participants. Seventeen obese and overweight Spanish women enrolled in a weight-loss treatment were recruited using a criterion sample strategy. Participants’ reported beliefs referring to the benefits of losing weight and the emotions related to dieting. The more positive these beliefs were, the more positive their attitude towards the diet seemed to be. Findings highlight the importance of follow-ups in creating a subjective norm to maintain a diet. Perceived behavioural control to diet seemed to be related to beliefs about social support; whereas beliefs about lack of willpower to overcome temptations seemed to decrease perceived control over eating behaviours.

Participants reported several beliefs and attitudes that offer plausible explanations of their eating behaviours. Data from this study seemed to fit the propositions of the TPB and could be used in further research to develop effective eating behaviour-change interventions. Doctors and Midwives could use the TPB to assess individuals’ attitudes, beliefs and expectations when following a diet. That assessment would provide insight into what aspects are relevant for individual patients when dieting, which could lead to more effective diet behaviour-change interventions being designed.

**Postpartum interventions**

Programmes focusing on restricting weight gain during pregnancy may be considered controversial by some because of the link between gestational weight gain and birth weight. If such a programme was effective enough to reduce weight gain to a level producing low birth-weight infants, there may be long-term metabolic implications, as those described by Barker’s Hypothesis. Therefore, an alternative approach would be to target maternal weight after birth.

One group recruited 90 women into a 6-month correspondence-style study with an intervention similar in design to that of Olson et al. published 5 years later. A pilot study had shown that new mothers were not willing to attend group sessions, even when free child-care was offered and so this method of delivery was chosen as previous successful community studies to prevent weight gain had been delivered by correspondence (53).

Women were eligible for participation in the study if they had given birth within the past year and had exceeded their prepregnancy weight by at least 6.8 kg. Women who were lactating or had a BMI of < 22 kg/m² were excluded. At baseline, the average BMI of this group of women was 29.8 kg/m² and the average weight above their prepregnancy weight was 12.3 kg. The control group received just two healthy living brochures, whereas the intervention group received two individual counselling sessions and 16 ‘lessons’ through the post on various aspects of leading a healthy lifestyle after birth. Each lesson contained a ‘homework’ assignment and the women were contacted by telephone at least biweekly to discuss progress. Women in the intervention group were encouraged to restrict their intake to between 1000 and 1500 kcal per day, reduce fat intake to 20% and begin gentle aerobic exercise, working up to walking 2 miles, five times a week. They were also advised how to involve their babies in their exercise.

During the 6-month intervention, 33% of the intervention group reached their prepregnancy weight compared with just 11.5% in the control group. Additionally, on average the intervention group lost 79% of their excess weight, whereas the control group lost 44%, a significant finding. This paper stated that it has been reported that at best, behavioural weight loss interventions achieve a loss of 9 kg in 6 months. On average, the women in the intervention group had
12 kg to lose to achieve their prepregnancy weight, therefore, had the intervention run for longer period, even better results may have been seen.

This study reports that the control group lost more weight than expected for the normal population. The authors postulate that the women involved in the trial could have been more motivated to lose weight than the average woman, as illustrated by almost a quarter of those in the control group joining a formal weight loss scheme such as Weight Watchers during the 6 months of the trial. This is an important criticism of the validity of the trial as it removes the ‘control’ aspect from the equation as the imposed intervention is being pitched against another form of weight loss in a quarter of cases. It could be assumed that, had the control women not joined a formal weight loss programme, the differences in weight loss between the two groups would have been even more pronounced. However, even though it was not reported, it is questionable whether any of the women in the intervention group also joined a formal weight loss programme on top of the intervention provided by the study. If restrictions on weight loss activity were not imposed on the control women at the start of the trial, it may be unlikely any were imposed on the intervention group.

According to self-reported values, energy expenditure did not change and both groups decreased their energy and percentage fat intake by a similar amount. This again brings into question the validity of self-reported measures. These outcome measures are notoriously inaccurate in even benign situations, but on the subject of weight and body image, reporting is likely to be influenced by external pressures to report an ideal rather than the truth and so be even more inaccurate. Many of the trials in this area of research include self-reporting in an attempt to correlate factors influencing observed weight loss. Ideally, a different method of data collection on energy intake and expenditure in studies of weight loss interventions is needed but exactly how this could be done without much restriction of the woman’s privacy and autonomy requires further research.

The women in the intervention group tended to be older individuals and a higher proportion were married. A similar number of dropouts was experienced by each group, all of whom were significantly heavier than those who completed the study. Heavier women were also less likely to have completed questionnaires about energy intake and expenditure even if they did finish the trial. This illustrates one of the difficulties in targeting overweight and obese women for any form of weight loss. As they are already struggling with their weight and may have low self-esteem and be embarrassed about their body image, bringing weight further to their attention may discourage them from using available services. For these women, it is important that their weight is addressed and focus must be placed on losing weight but they may require extra support to help them psychologically accept and cope with a weight loss programme.

A randomised control trial used local media to recruit 40 women between 6 weeks and 6 months postpartum, however, only 23 completed the study, which lasted 1 year (54). All the women were overweight (BMI >25 kg/m²) prepregnancy, had gained more than 15 kg during pregnancy exceeding IOM guidelines and were at least 5 kg over their prepregnancy weight at enrolment. They were randomised to a structured or a self-directed programme. Those on the structured programme received individualised diet and exercise prescriptions, were asked to keep diaries of progress and to attend regular group sessions. A 12-week meal plan and a heart rate monitor were also provided to help the women achieve their goals. Those in the self-directed group met once with a dietician and once with an exercise physiologist for brief advice on healthy lifestyles and then monitored their own progress. Both groups were advised to reduce their daily calorie intake by 350 kcal and increase their output by 150 kcal, creating a 500 kcal per day deficit.

On average, at 12 weeks the structured intervention group had lost 5.6 kg and at 1 year postpartum, they had lost 7.3 kg. Five out of the 13 women who completed in this group also reached a BMI < 25 kg/m² at 1 year postpartum. In the self-directed group, there was no significant change in body mass or percentage body fat and none reached a BMI < 25 kg/m². Correlations were seen between the weight loss in the structured group and their energy intake/output logs. It is possible that self-reporting in this trial was better than the average as all women in this study were trained how to report, for example, equating a deck of cards size piece of meat to 300 g.

One reason for the high drop out rate in this trial could have been the inclusion of three treadmill tests that involved apparatus to analyse gas exchange. The use of such equipment can be off-putting so despite an increase in accuracy of fitness measurement per person, the overall validity of the trial was reduced as fewer women completed the study. However, the authors of this study proposed that if a woman can commit to 1 h exercise a week for the first 6 months postpartum, she will have the tools and the motivation to lose weight and keep it off by 1 year postpartum, clearly favouring the individualised, structured methods.

The most recent study of postpartum weight loss was reported by the same authors of the Finish trial
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described in the interventions during pregnancy section of this review. The same methods of recruiting only primigravidas onto a programme of dietary advice and exercise were followed and this advice was delivered at five postnatal clinic visits from 2 to 10 months postpartum. An optional group exercise class was also offered to the intervention group, in which half of the women participated.

The results of this study showed that although 50% of the intervention group reached their prepregnancy weight, compared with just 30% in the control group, of those who did not return to their prepregnancy weight, the intervention group retained more excess weight than the controls. Therefore, overall, there was no statistical significance in the differences in weight loss between the two groups. Very few women dropped out of this study, but as seen before, they tended to have a higher prepregnancy and postpartum weight and so had a bigger challenge to face.

The authors suggest that having infants present at the postpartum counselling sessions may have reduced their efficacy and so the outcome of the intervention. This is just one example of how a newborn infant can interfere with the life and goals of new parents, often the mother in particular. Finding the time and energy to exercise and choose healthy foods rather than the easy fast food or microwave meal options when a new born infant is demanding attention both day and night is no easy task. One study has suggested the sooner new mothers return to work, the less weight they retain at 6 months postpartum as they have more distractions, are more active and spend less time around food (55). It is also likely they will have some form of child-care if they have returned to work and so perhaps be less drained both physically and emotionally.

A small qualitative study targeted at young African American women attempted to define some of the barriers to postpartum weight loss (56). Four small discussion groups of women with an average BMI of 31 kg/m² highlighted areas of concern within their community. They expressed a general desire to lose weight and felt aware of the implications of obesity on their health and pregnancy although not of ways to diet and exercise properly. They felt the key barriers to weight loss were the cost, the need for child-care, depression and image-related confidence issues, traditional cooking habits and previous experiences of weight changes with pregnancy. The overwhelming preference for an intervention was one that provided a structured and supportive programme from people who understood the challenges of motherhood. Locality and child-care provision were also important with a desire to include the whole family in goal setting and behaviour change.

Lactation

Theoretically, it was thought that lactation promoted postpartum weight loss. However, research has shown that the effect of lactation on weight retention can vary (57) and in the long-term, breast-feeding does not affect weight retention (58). The safety of weight loss during lactation for the suckling child has been cause for concern and it is recommended that women who are exclusively breast-feeding should not lose more than 2 kg per month (59). However, there have been no randomised trials to support this recommendation.

The following trials primarily evaluated a weight loss intervention in terms of the effect on lactation and growth of the infant, with maternal weight loss achieved as a secondary outcome measure. Lovelady et al. (60) randomised overweight women who were exclusively breast-feeding at 4 weeks postpartum to a control group and one which was instructed to restrict their daily calorie intake by 500 kcal and do four 45-min exercise sessions per week. To assist, women in the intervention group were provided with six low-calorie, low-fat frozen meals per week and exercise was monitored by research assistants. The intervention group lost between 1.7 and 8.3 kg in 10 weeks, in relation to the control group who varied between losing 4.6 kg and gaining 4.6 kg. In both groups, it was noted that predominantly fat mass was lost. After 6 months, 48% of the intervention group were within 1 kg of their prepregnancy weight where as only 21% of the control group reached the same target. No significant differences were noted between the groups in terms of infant growth.

Dewey and McCrory (59) looked at the safety of exercise alone as a means of weight loss for the lactating woman and her child. They found no adverse effects on milk production or growth of the children during a 12-week programme of five 45-min sessions of aerobic exercise per week. In terms of a weight loss intervention, the important point to note from this study is that both exercise and diet control are necessary for a successful intervention. Diet was not controlled in this study and no differences were seen in the amount of weight lost in the active and sedentary group. Without restriction, the women participating in the exercise sessions tended to increase their energy intake to compensate.

Summary

Pregnancy could be a key time to target a weight control or weight loss intervention to help curb the rapidly increasing prevalence of obesity in the population. Pregnancy is traditionally a time when women feel they should be ‘eating for two’ and resting, but
it is also a time when behaviours can be challenged with the aim of not only improving the woman’s health, but more importantly from a motivational point of view, the health of her baby. Effective interventions have been seen to promote smoking cessation in pregnancy, could the same be true of targeting diet and exercise behaviours if the correct support and guidance are available?

There have been numerous calls for further research into all areas in the field of obesity and fertility (61,62) and the limited evidence published to date, reviewed in this article, provides a baseline from which to build. When designing subsequent studies, the following recommendations may improve the efficacy of the intervention and the reliability of results.

Learning points for future research

• The attitudes towards weight control during the reproductive period of a woman’s life need to be addressed and on a national level, the population needs to be better informed on the risks of obesity and pregnancy.
• Sample sizes should be larger.
• Study samples should include only primiparas women as experience of pregnancy may influence the expectations of weight change during pregnancy and so adherence to the intervention.
• Women should be divided into groups by weight categories using BMI or another, more accurate measurement of body mass such as waist-to-hip ratio.
• A cut-off limit should be chosen which is representative of the current population. This is likely to be higher than the traditional 25 kg/m².
• All weight measurements should be taken in front of a health professional or research assistant and a better recording system of dietary and exercise effort needs to be developed.
• The intervention design should consider:
  1. The general success of an individual, structured programme with self-control over monitoring progress.
  2. Ways to overcome the difficulties motivating overweight and obese women to lose weight. Additional support and psychological interventions may be necessary.
  3. The barriers encountered by women of a low socio-economic status. The intervention should acknowledge the education level and accessibility of health services to the target population.
  4. Any costs incurred by the intervention including the price of healthy food, gym membership and childcare facilities.
  5. Targeting the type of food eaten rather than quantity.
  6. The amount of time and energy a woman is able to devote to a weight loss intervention in the postpartum period.
  7. Involving the newborn child in exercise regimes for the postpartum period.
  8. Identification of women suffering from postpartum depression and provide additional support.
  9. Involving the whole family in the intervention to promote a behaviour change in the home that will continue beyond the study.

• Study analysis should exclude women with GDM as this may skew the results of an intervention on obesity alone as there is an additional metabolic interaction.
• Studies should account for differences in ethnicity when grouping and analysing results.
• Studies should evaluate and account for weight changes in those women who quit smoking during the time of the intervention and perhaps provide additional nutritional advice for those who do.
• To date, there are no long-term observations or follow up studies associated with interventions for obesity in pregnancy. This would be an essential extension to any future trial.

CEMACH Maternal Death Enquiry (63) found that 35% of women who died between 2000 and 2003 were obese and that 30% of mothers who had a stillbirth or neonatal death were also obese. This is much higher than the background rate of obesity in the antenatal population. As a result, obesity has been selected as the principal objective for CEMACH’s projects with a maternal focus for 2008–2011.

Because of the lack of guidance it is unclear what, if any, evidence-based practice is being followed throughout the healthcare centres in the UK. Therefore, CEMACH are launching a project which focuses on the care of pregnant women with a BMI > 35 kg/m². They are aiming to assess current practice, produce guidelines and follow up with an audit of women cared for using the developed guidelines. This, together with future research into the efficacy of interventions targeting obesity in pregnancy, should provide direction to address the growing concern in the field of obstetrics and gynaecology.

Key points

• The prevalence of obesity is on the rise world-wide. Globally, a 50% increase was reported from 1995 to the year 2000 and current estimates from the International Obesity Task Force suggest that today, over
300 million adults are obese and a further 1 billion are overweight.

- Obesity has not only been associated with poor obstetric outcomes, it also poses a significant burden on the personnel and finances of the NHS.
- A key component of this dramatic increase is the cycle of obese parents producing offspring with a tendency for childhood obesity, who then become obese parents themselves, thereby perpetuating the problem.
- Although much is known about adverse effects of obesity in pregnancy, there is a deficiency of appropriately designed interventions for maternal obesity.
- Pregnancy could be the right time to implement positive lifestyle changes.
- The attitudes towards weight control during the reproductive period of a woman’s life need to be addressed and on a national level, the population needs to be better informed on the risks of obesity and pregnancy.

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