Research Article

Maternal anthropometry and pregnancy outcomes: a proposal for the monitoring of pregnancy weight gain in outpatient clinics in South Africa

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The aim of this review was to develop a framework for the monitoring of pregnancy weight gain in South African outpatient clinics. Studies showed that intrauterine malnutrition have more serious consequences for children than postnatal malnutrition. Undernutrition, as well as overnutrition during pregnancy, was associated with adverse pregnancy outcomes. The IOM published recommended weight gains by pre-pregnancy body mass index (BMI). Wasting in pregnant women can be defined as a mid-upperarm circumference (MUAC) < 22cm. Low prepregnancy BMI is considered a risk factor for preterm birth and intra-uterine growth retardation. Pregnant women in developing countries start to attend antenatal clinics late in pregnancy, so that prepregnancy BMI may be unknown and antenatal care can be based on pregnancy weight gain only. A framework is proposed that identifies the critical points for action during pregnancy to improve birth outcomes. Health care providers should measure height, weight and MUAC and try to classify pregnant women according to weight status, set weight gain goals and monitor gestational weight gain between follow-up visits. Women with short stature (<145cm), low body weight (<45kg), and/or MUAC<22cm are considered to be at risk of adverse pregnancy outcomes. Weekly weight gains should range from 0.3kg for overweight women to 0.5kg or more for underweight women from the second trimester. Genetic background, age, general health, HIV and educational status, cigarette smoking, past nutritional status of the mother, parity, multiple pregnancies, climate, socioeconomic conditions and the availability of health services should be adjusted for in statistical analyses.

Introduction

Maternal nutritional status is considered to be an important factor that affects the successful completion of pregnancy (Abrams & Selvin 1995:163). In extreme cases of chronic undernutrition, low energy intake during pregnancy was associated with low birth-weight (LBW) (Eastman & Hellman, 1966:326). However, the effect of moderate malnutrition on foetal growth is not clear. Other interacting factors, such as racial and genetic background, age, general health, educational status, cigarette smoking, past nutritional status of the mother, parity, multiple pregnancies, climate, socioeconomic conditions related to sanitation and infections, and the availability of health services make interpretation of the association between maternal nutrition and foetal development difficult. Although the importance of these factors in comprehensive maternal care is recognized, this review will be limited to the background for a protocol for the monitoring of pregnancy weight gain. Some 200 million women become pregnant each year, most of them in developing countries. Many of these women suffer from long-term cumulative consequences of undernutrition since childhood (WHO, 1997). Malnutrition in women remains, to a large extent,

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unreported (Mora & Nestel, 2000:1353S).

Obesity among women of reproductive age has been related to several gynaecological disorders, including polycystic ovary syndrome, infertility, menstrual disorders and pregnancy hypertension (Lake & Cole, 1997:432). According to a national South African study 56.6% of women older than 15y were overweight or obese (BMI >/= 25 kg/m^2) (Puoane, Steyn, Bradshaw, Laubscher, Fourie, Lambert & Mbananga, 2002:1038). Data on pregnancy weight-gain patterns from developing countries are scarce, due to difficulties in collecting data throughout pregnancy (Winkvist, Stenlund, Hakimi, Nurdati, Dibley, 2002:1072). There are very limited data available about weight gain patterns of pregnant South African women and the effects of pregnancy weight gain on birth outcomes. Due to this shortage of data there are no clear recommendations for the monitoring of pregnancy weight gain in South African outpatient clinics. More specifically, critical points of action and referral to specialised nutritional care are currently not clearly identified for primary antenatal health care settings (Department of Health, 1996). Only after a comprehensive review of the existing knowledge can such recommendations and areas of further research be pointed out.

Aim

The aim of this review is to provide a background for a protocol for the monitoring of pregnancy weight gain in South African outpatient clinics and to highlight areas where further research is needed.

Maternal malnutrition and foetal development

Chronic limitation of energy intake during pregnancy is associated with LBW (Lechtig, Habicht, Delgado, Klein, Yarbourgh & Martorell, 1975:508; Mardones-Santander, 1999:970). However, in some studies supplemented groups also benefited from improved general health care, which could have affected the results (Gabr, 1981:90). Evidence showed that malnutrition *per se* alters the metabolic, structural and functional capabilities of the central nervous system of the foetus and limits mental performance. The reduction in total brain mass was directly proportional to the reduction in head circumference (Keusch, 1977:555). Head circumference of the foetus increased as a result of food supplementation during pregnancy (Lechtig *et al.*, 1975:508). Small-for-gestational-age babies of malnourished mothers show defects in defence mechanisms, such as a decreased number of T-lymphocytes, hypoglobulinemia and impaired chemotaxis (Keusch, 1977:555). These results suggest that intrauterine malnutrition may have more serious consequences than postnatal malnutrition (Lechtig *et al.*, 1975:508, Gabr 1981:90). Eclampsia of pregnancy occurs most commonly among women who are overweight at conception, or those who gain weight excessively during pregnancy. Eclampsia has, however, also been described among women who were underweight at conception and those who failed to gain normal weight during the course of pregnancy (Gopalan 1985:203).

Energy balance during pregnancy

The total energy requirement of pregnancy has been established at 335 000kJ or 1200kJ daily above the non-pregnant energy requirement (WHO, 1985:84). The recommendation is based on calculations which were rounded upwards twice to the recommended daily allowance (RDA) for pregnancy (Anon, 1985:110). This recommendation may be too liberal, since adaptation and decreased physical activity during pregnancy decrease the energy requirement. Longitudinal studies on healthy pregnant women in several countries were done to ascertain energy intakes associated with normal pregnancy outcomes. Energy intakes rose by only about 420kJ per day for the total period to the late stage of pregnancy. The mean additional energy supplied by dietary intake in healthy women who produced healthy babies of normal weight was less than 84 000kJ, or the equivalent of about 300kJ daily above the non-pregnant energy requirement for the first 36 weeks and 800 to 1200kJ extra for the final four weeks (Durnin, Grant, McKillop & Fitzgerald, 1985:823). Data from the Gambia showed that the proper safe daily energy supplementation could be about 840kJ per day, instead of the American recommendation of 1200kJ extra per day (Lawrence, Lamb, Lawrence & Whitehead, 1984:363). Research on optimal energy requirements during pregnancy is needed, in order to be able to formulate appropriate interventions to improve pregnancy outcomes.

Studies in pregnant Indian and African women showed that basal energy expenditure (BEE) during the first trimester of pregnancy was not significantly different from the BEE of non-pregnant women. BEE was significantly increased during the second and third trimester (Das & Jana, 1998:281; Durnin *et al.*, 1985:823). They calculated that unless a pregnant woman increased her physical activity during the first 30 weeks of pregnancy, there would be no increase in the demand for energy (Durnin *et al.*, 1985:823). There is considerable inter-individual variation in the metabolic response to pregnancy among well-nourished women (Goldberg, Prentice & Coward, 1993:494). In a group of well-nourished pregnant women basal metabolic rate (BMR) at 24 weeks gestation was significantly related to body weight and fat. These data suggest that thin mothers are energy sparing, while fat mothers are energy wasting and that maternal pre-pregnancy energy status is one of the determinants of change in BMR during pregnancy (King, Butte, Bronstein, Kopp & Lindquist, 1994:439S).

Maternal physical activity in relation to total energy expenditure

Pivarnik (1998:400) reviewed the potential effects of maternal physical activity on birth weight. Job-related physical activity was related to unfavourable birth outcomes, including premature delivery and LBW, but most studies have not controlled for socio-economic status. Participation in moderate to vigorous activity throughout pregnancy may enhance birth weight, while more severe activity regimes may result in lower infant birth weights and smaller neonatal head circumference (Rao, Kanade, Margetts, Yajnik, Lubree, Rege, Desai, Jackson, & Fall, 2003:531). The effects of physical activity should be assessed in relation to energy intake to determine the effects of energy balance during pregnancy on pregnancy outcomes.

Energy balance may be changed in any of the following ways to meet the requirements for pregnancy, namely a reduction in BMR, mobilisation of maternal fat stores, a reduction in physical activity, or an increased food

Table 1 Recommended total weight gain during pregnancy by pre-pregnancy BMI#

BMI category (kg/m^2)	Recommended total weight gain (kg)*	Second and third trimester weekly weight gain (kg)
Low (BMI<19.8)	12.5-18	0.49
Normal (BMI 19.8-26.0)	11.5-16	0.44
High (BMI>26.0-29.0)	7-11.5	0.3
Obese (BMI>29.0)	6	

BMI = body mass index

* Adolescents and black women should strive for gains at the upper end of the recommended range, while short women should strive for gains at the lower end of the range (IOM, 1990:1, Feig & Naylor, 1998:1054).

intake. Underweight women, living under constraints of hard physical work and limited food supply cannot increase their food intakes and can also not modify their activity patterns. Since a woman living under these conditions also generally has little fat reserves to mobilise, her only option is a reduction in BMR. The severity of the situation will determine whether the infant will be small for gestational age at birth. A normal weight woman in developed countries could either increase her food intake, or reduce her physical activity. Hormonal changes of pregnancy facilitate fat deposition and pregnant women living under these conditions tend to gain additional fat stores. Apparently the body senses that there is no need to conserve energy and BMR per kg fat-free mass increases slightly. No studies have been done to assess changes in food intake, activity patterns or mobilisation of fat stores of obese pregnant women. Apparently BMR in late pregnancy can be increased by about 20% above that of non-pregnant overweight women, in order to offset the potential for fat deposition in already obese women (King *et al.*, 1994:439S).

Weight gain during pregnancy

In the 1960s weight gain during pregnancy was restricted to "preferably 6.8kg" in order to prevent toxaemia and difficult births (Eastman & Hellman, 1966:326). In 1970 the National Academy of Sciences Subcommittee concluded that strict measures that distort normal prenatal weight gain increase the risk of LBW and increased the formal recommendation for pregnancy weight gain to 9-11.4kg (NRC, 1989). The liberalisation of the weight-gain recommendations was associated with increased means of both pregnancy weight gain and infant birth weight (Abrams, 1994:515). The Institutes of Medicine (IOM) published recommended weight gains by pre-pregnancy BMI in 1990 (Table 1). An overall weight gain during pregnancy of 11.5-16kg is considered appropriate for a woman of normal weight. A total gestational weight gain for women with twin pregnancies is 16-20.5kg.

Feig and Naylor (1998:1054) critiqued the IOM recommendations and recommended a weight-gain range of 7-11.5kg for women with a normal pre-pregnant BMI, which is closer to the recommendations of 30 years ago. They stated that weight gains within the IOM recommendations will produce obese mothers and overgrown babies, necessitating caesarean deliveries. Nestel and Rutstein (2002:17-27) reviewed data from 46 national surveys in 36 developing countries for women aged 15-49 years. Women in the lowest category of BMI were more likely to have infants with LBW and also had worse outcomes of neonatal mortality.

Monitoring body composition during pregnancy

The practice of weighing pregnant women as routine part of clinical practice has been criticised. Studies of the usefulness of weight monitoring during pregnancy concluded that maternal weight gain alone is neither a sensitive, nor a specific predictor of poor pregnancy outcome (Theron & Thompson, 1993:269; Abrams, Altman & Pickett, 2000:1233S). Although weight gain may not be a good screening tool, weight gains outside the IOM's recommendations are associated with twice as many poor pregnancy outcomes than are weight gains within the recommended range. Caulfield, Witter & Stolzfus (1997:1984) found that women with low weight gains were more likely to be young, short, thin, less educated, smokers and black, than were women with weight gains within the recommended range. Women with excessive weight gains were more likely to be tall, heavy, primiparous, white and hypertensive. These findings suggest that weight monitoring in pregnancy could help clinicians to target women at high risk of poor pregnancy outcome (Feig & Naylor, 1998:1054). Published studies showed that only 30-40% of women in the USA actually have weight gains within the IOM recommended ranges (Caulfield *et al.*, 1997:1984; Hickey, Cliver. McNeal, Hoffman & Goldenberg, 1995:909). There is a lack of data on pregnancy weight gains of South African women.

Pregnancy weight gain is generally accompanied by increases in subcutaneous fat early in pregnancy, but skinfold thickness decreases during the third trimester when foetal energy demands are the greatest (Adair & Pollitt, 1982:219). This increase in fat stores during the first two trimesters was found even in Gambian and Taiwanese women who had energy intakes below 7600kJ during the third trimester, which is below the generally accepted recommendation for pregnancy. The authors suggested that these populations have adapted successfully to limited food intake over long periods of time, by making metabolic adjustments that contribute to an increased potential for gaining fat and reproductive success (King *et al.*, 1994:439S, Adair & Pollitt, 1982:219).

The subscapular skinfold thickness is a better predictor of insulin resistance in pregnant women than BMI. Most of the adipose tissue retained during pregnancy is stored subcutaneously on the trunk and maternal visceral adiposity increases minimally during gestation (Stevens-Simon, Thureen, Barrett & Stamm, 2002:563). It is, however difficult to obtain reproducible measurements of skinfold thickness, especially in obese individuals. Skinfold measurements are not clinically useful, because there are no validated equations to predict total body composition of pregnant women from skinfold measurements and reference standards for skinfolds have not been validated against foetal outcomes (IOM, 1990:1).

Wasting in pregnant women can be defined as a mid-upper arm circumference (MUAC) < 22cm (Villamor, Msamanga, Spiegelman, Coley, Hunter, Petrson, Fawzi, 2002:415). In a study in Tanzania HIV infection was a significant risk factor for wasting among pregnant women, particularly in groups of low socioeconomic status (Villamor *et al.*, 2002:415). BMI, defined as weight in kg divided by height in meters squared [weight/(height)^2], is still considered a simple, useful index for evaluating prepregnancy nutritional status in clinical settings (IOM, 1990:1). Low prepregnancy BMI is considered a marker for minimal nutrient reserves and a risk factor for preterm birth and IUGR (Schieve, Cogswell, Scanlon, 2000:415). An even simpler index of risk for IUGR is a low prepregnancy weight of the mother. In a large prospective study of black indigent women a low prepregnancy weight (<50kg) had the strongest relationship with preterm delivery, with an adjusted odds ratio of 2.72. There was also a three-fold increase in risk for IUGR in women with low prepregnancy weight, after adjustments were made for other confounders (Wen, Goldenberg, Cutter, Hoffman & Cliver, 1990:213). Calculating BMI provides a systematic method for distinguishing between women of different heights, thus measuring height at the first visit is recommended (Institute of Medicine, 1990:5).

A major problem in developing countries is that pregnant women start to attend antenatal clinics in a late stage of pregnancy, so that prepregnancy weight and BMI may not be available (Dannhauser, Bam, Joubert, Nel, Badenhorst, Barnard, Slabber, Badenhorst & Du Toit, 2000:38) and antenatal care can then be based on rate of pregnancy weight gain only. In many cases gestational age is also uncertain. It is, however, recommended that health care providers should try to classify pregnant women according to weight status, set weight gain goals and monitor gestational weight gain, using consistent, reliable procedures to measure weight at follow-up visits. Gestational age should be estimated from date of last menstruation, if known and supplemented by obstetric clinical examination (measurement of uterus fundal height) and ultrasound examination, where available. A weight gain chart should be used to plot weight by week of gestation, with a notation if gestational age is uncertain. The Subcommittee on Nutritional Status during Pregnancy of the Institute of Medicine (Institute of Medicine, 1990:12) recommended weekly weight gains ranging from 0.3kg for overweight women to 0.5kg or more for underweight women from the second trimester of pregnancy (Table 1). Trends of rate of weight gain can then be followed, since a wide range of weight gains is compatible with desirable pregnancy outcomes. Marked or persistent deviations from the prescribed rate of weight gain should be investigated (Table 2).

Women with established weight gain deviations should receive individualised counselling about diet and physical activity, if inappropriate food intake or physical activity patterns are found. Erratically high weight gain is likely to represent excessive fluid retention, which can be clinically determined as ankle oedema. A sharp increase in weight gain, generalised oedema and hypertension indicate pre-eclampsia, a serious pregnancy complication (Institute of Medicine, 1990:9).

Pregnancy weight gain and foetal outcomes

A rate of pregnancy weight gain below the lower limit of the IOM recommended range is associated with risk of preterm birth (Institute of Medicine, 1990:10, Hickey *et al.*, 1995:909). The biological mechanism underlying this association is unknown (Eastman & Hellman,

Table 2 Gestational weight gain cut-off points showing deviations from the expected weight gain pattern

BMI# category of pregnant woman	Weight gain per month of pregnancy	Action
Overweight/obese	<0.5kg	Check for measurement or recording errors, differences in clothing or time of day
Normal weight	<1kg	Determine cause Implement corrective action
Overweight/obese/normal weight	>3kg	Check for measurement or recording errors, differences in clothing, oedema, multiple gestations Determine cause Implement corrective action

BMI = body mass index

1996:326), but may in part be a lack of protein-energy availability to the foetus. Mothers with a low prepregnancy BMI, but normal pregnancy weight gain may still be at risk of preterm delivery, because changes in maternal haemodynamic status apparently prevent the foetus from receiving an adequate nutrient supply (Rosso & Salas, 1994:2).

Insufficient weight gain in pregnancy was associated with LBW (<2500g), while excessive maternal weight gain was associated with macrosomia (>4000-4500g) and increased risk of birth injury (Cogswell, Serdula, Hungerford & Yip, 1995:705). The incidence of high birth weight did not, however, increase dramatically until pregnancy weight gain exceeded 16kg, the upper limit of the IOM recommended range (Feig & Naylor, 1998:1054). A study of trimester weight gain and birth weight in 3000 white women in the USA showed that weight gain in the second trimester was more strongly associated with foetal growth than was weight gain in the first or third trimester (Abrams & Selvin, 1995:163).

More than 7 million newborn deaths per year are associated with maternal health and nutrition-related problems resulting from poorly managed pregnancies and poor perinatal care (WHO, 1997). Malnourished women are more likely to have stillbirths or to deliver LBW babies, suffering from reduced immune competence (Keusch, 1977:555) and suboptimal cognitive development and learning capacity (Gabr, 1981:90). A study in low-income pregnant women in the USA showed that infant birth weight correlated significantly with the mother's weight at the time of delivery ($r=0.517$, $P<0.001$), pre-pregnancy BMI ($r=0.31$, $P<0.05$) and weight gain during pregnancy ($r=0.388$, $P<0.05$). Stepwise regression analysis showed that four variables, namely mother's weight at time of delivery, pre-pregnancy BMI, number of intervention visits by a nutritionist and change in energy intake from pre-intervention diet to after the nutrition intervention explained 65% of the variation in infant birth weight (Winick & Rosso, 1969:181).

Briend (1985:38) suggested that a direct limitation of foetal growth by maternal energy reserves seem unlikely. He argued that foetal growth may be adapted to produce a baby with a size compatible with the energy reserves of the mother for lactation. It would be advantageous that a malnourished mother gives birth to a small baby with small energy needs. The author also suggested that obese women often give birth to small babies, because they may be prone to cardiovascular problems resulting in poor foetal growth. There is no evidence that maternal fat stores benefit foetal growth among normal weight women (Widga & Lewis, 1999:1058). These results support the hypothesis that infant birth weight is not associated with maternal energy reserves, but rather with maternal lean body mass. These results also showed that the effect of one variable on infant birth weight cannot be studied in isolation. The state of energy balance (dietary energy intake minus energy expenditure) appears to exert a greater influence on foetal growth than energy intake or energy reserves.

Two well-controlled studies showed that the risk of caesarean delivery increased with both pre-pregnancy weight and increasing weight gain of the mother (Lawrence *et al.*, 1991:254; Witter, Caulfield & Stolzfus, 1995:947). The relationship between maternal weight gain and caesarean delivery was continuous and the authors could not identify a threshold above which the risk of caesarean delivery increased more rapidly.

Confounding factors affecting the association between pregnancy weight gain and birth-weight

De Onis, Villar & Gulmezoglu (1998:S83) questioned whether a single intervention could reduce the rate of a multi-causal outcome such as IUGR that is dependent on socioeconomic disparities, since many socio-economic factors have an effect on infant birth-weight. Generally age does not modify the effect of weight gain on foetal growth, except in very young adolescents, who tend to have smaller infants for the same pregnancy weight gain than older women (Institute of Medicine, 1990:8). Increasing caffeine consumption of the mother, smoking and psychosocial stress were significantly associated with IUGR in mothers with a low prepregnancy BMI. A BMI higher than 22 kg/m^2 seemed to protect against the adverse effects of smoking and stress in a population of poor black women (Cliver, Goldenberg, Cutter, Hoffman, Copper, Gottlieb & Davis, 1992:262; Vlajinac, Petrovic, Marinkovic, Sipetic & Adanja, 1997:335).

Pregnancy weight gain and maternal outcomes

Optimal maternal outcomes were found in mothers with weight gains within the IOM's recommended ranges (Table 1) (Feig & Naylor, 1998:1054). The definite negative outcome of poor prenatal nutritional status is reflected in the high prevalence of maternal mortality in developing countries, namely almost 600 000 maternal deaths per year (World Health Organization/United Nations Children's Education Fund, 1996). The extent of the contribution of maternal nutritional status and poor pregnancy weight gain to the mortality rate is unknown, but it has been established that stunted women are at a higher risk of obstructed labour as a result of cephalo-pelvic disproportion. Chronically energy deficient women with short stature (<145cm) and low body weight (<45kg), or both are considered to be at risk of adverse pregnancy outcomes (Royston & Armstrong, 1989). Obese women are more likely to deliver infants with macrosomia, or with intrauterine growth restriction, or who require admittance to an intensive care unit than do their normal-weight counterparts (Perlow & Morgan, 1994:560). Obese pregnant women also have a higher likelihood of caesarean delivery and peri-operative morbidity after caesarean delivery, as well as urinary tract infections than do normal weight women (Parker & Abrams, 1993:768; Perlow & Morgan, 1994:560).

Among women who successfully breast-fed for more than two weeks, those who were obese at one month postpartum were more likely to discontinue breast-feeding before their babies were three months old than those who were of normal weight (Kumanyika, 1999:1). Women who were overweight had less success initiating breastfeeding than did their normal-weight counterparts (Hilson, Rasmussen & Kjolhede, 1997:1371). Higher rates of discontinuation of exclusive breastfeeding was also found in obese women, suggesting that excessive fatness in the reproductive period may inhibit lactational performance (Rutishauser & Carlin, 1992:559).

Obese women are more likely than normal weight women to suffer from hypertension and/ or diabetes mellitus during pregnancy (Parker & Abrams, 1993:768; Perlow & Morgan, 1994:560). Stevens-Simon *et al.* (2002:563) reported a significant increase from conception in fasting serum insulin and glucose-to-insulin ratio in pregnant women at 30 weeks gestation and that insulin resistance was significantly related to total and subcutaneous adiposity. Subscapular skinfold thickness and ultrasonically measured subcutaneous fat at the costal site were the best predictors of insulin resistance. Obesity at the age of 23 years was associated with an increased risk of hypertension in pregnancy in the British birth cohort study. After adjusting for confounders, obese women had an odds ratio of 3.02 (95%CI 1.96, 4.63) to be hypertensive (Lake, Power & Cole, 1997:432).

With increasing rates of obesity world-wide, postpartum weight retention is an important pregnancy outcome. Studies reviewed by the IOM's Subcommittee on Nutritional Status during Pregnancy (1990:12) suggested an average weight retention of 1kg per birth. A study of postpartum weight retention showed that white women who gained more than 16 kg were more likely to retain more than 6kg postpartum. Black women showed a greater increase in postpartum weight retention with increasing pregnancy weight gain and were more likely to retain more than 6kg than were white women (Keppel & Taffel, 1993:1100). This difference in weight retention after pregnancy has been mentioned as one of the determinants of a higher prevalence of obesity among black women compared to white women (Kumanyika, 1999:1). Since black women have an increased risk of excessive postpartum fat retention, the recommendation that black women should strive for pregnancy weight gains at the upper end of the IOM recommended range (Table 1) should probably only be applied for underweight black women. This recommendation has been made due to the observation that black infants tended to be smaller than white infants for the same gestational weight gain of the mothers. In another study postpartum weight retention was studied in women who began their pregnancy with a normal BMI. After adjustment for confounding variables women whose pregnancy weight gain exceeded the IOM's upper cut-off of 16kg were twice as likely to retain more than 9kg 10-24 months postpartum than were women whose weight gains were within the IOM's recommended ranges (Perlow, Morgan, Montgomery, Towers & Porto, 1992:958).

The relation between pregnancy weight gain and both birth weight of the baby and postpartum weight retention was studied in young low-income women with normal pre-pregnancy BMI. Those with weight gains above the IOM's recommended ranges had significantly higher mean postpartum BMIs than those with weight gains within the IOM's recommended ranges (25.8 versus 23.5 kg/m^2). Despite the greater postpartum BMIs in the group with excessive weight gain, neither birth weight nor gestational age was significantly different from those with normal weight gains (Scholl, Hediger, Schall, Ances & Smith, 1995:423). It was suggested that subscapular skinfold thickness, as a predictor of insulin resistance could help to clarify the physiologic mechanism underlying the partitioning of nutrients between maternal and foetal tissues (Wen *et al.*, 1990:213). Pregnancy is considered as a significant factor in the development of obesity for many women. Factors associated with excessive weight retention during pregnancy include total weight gain during pregnancy, ethnicity, dietary patterns and interval between pregnancies (Lovejoy, 1998:1247). Maternal metabolic adaptations during pregnancy include decreased insulin sensitivity, which correlates inversely with accretion of adipose tissue in early pregnancy (Neggers & Goldenberg, 2003:1737S).

Integrated intervention

An integrated approach is essential for the development of an effective practical programme to combat maternal malnutrition (Gopalan, 1962:203). Risk assessment should be used for targeting high-risk pregnancies to ensure specialised care for those in need. It is, however, difficult to develop a simple, single screening tool, but anthropometric measurements can help to identify pregnant women at risk of delivering LBW babies (Mora & Nestel, 2000:1353S). Figure 1 shows a proposed framework for the management of pregnancy weight gain.

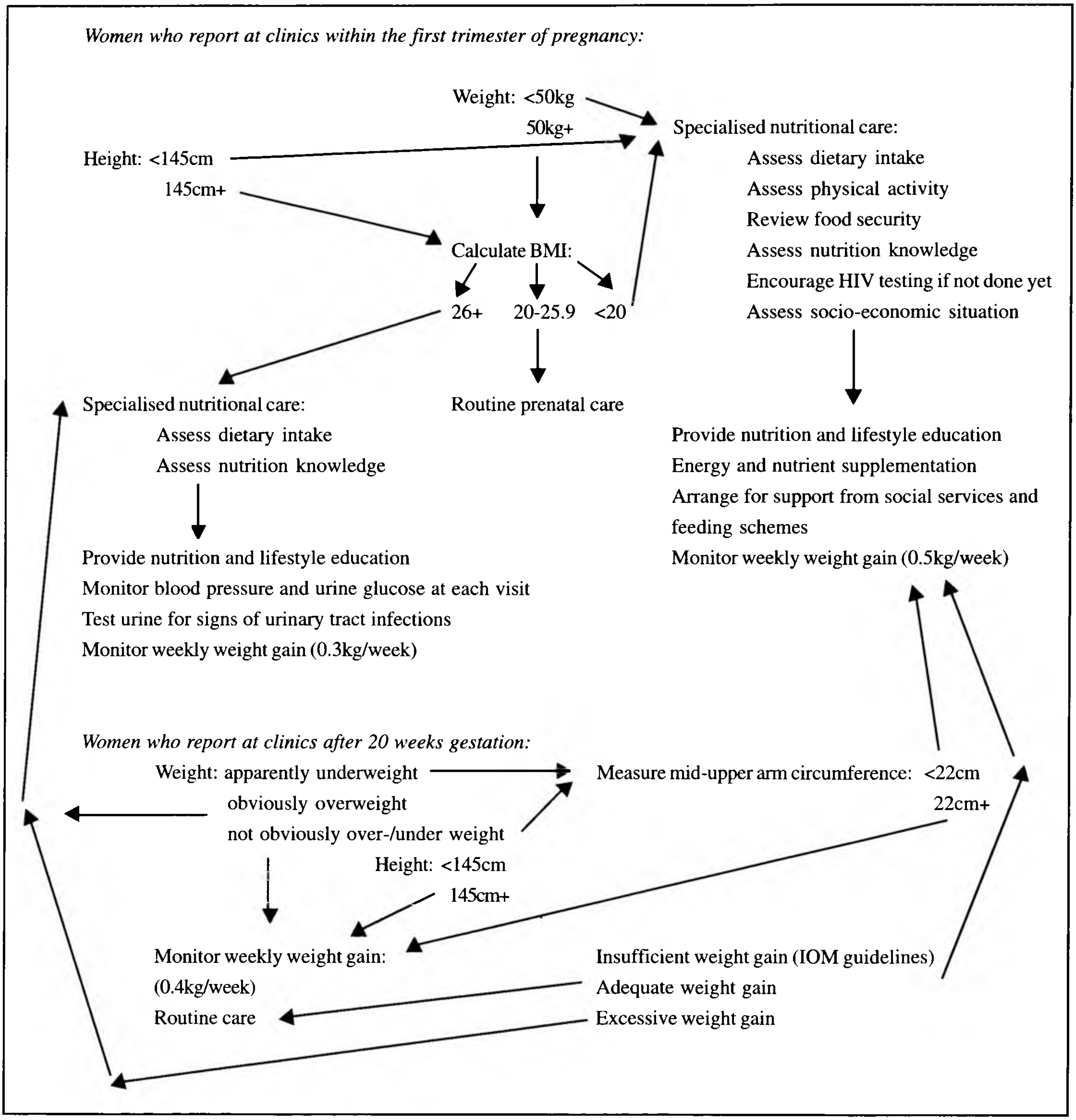
Mora and Nestel (2000:1354S) proposed a conceptual framework that identifies the critical points for action to improve women's health. The best dietary counsel to well-nourished normal-weight pregnant women is probably to eat to appetite. Health providers should explain to underweight women why weight gain is important and they should be counselled to promote a balanced diet consistent with cultural and financial considerations (Dawes, Green & Ashurst, 1992:487). Undernourished women should receive food supplements for at least the last trimester of pregnancy to improve pregnancy outcomes (Eastman & Hellman, 1966:326). Special attention to foods rich in micronutrients or supplements of iron, calcium, vitamin C and folic acid may help to decrease the risk of IUGR (Mardones-Santander, 1999:970), since micronutrients may be a limiting factor for foetal growth (Catalano, 1999:S124). Overweight women should receive advice about a balanced diet and be monitored to prevent excessive weight gain above the IOM recommendations (Dawes *et al.*, 1992:487).

Conclusion and recommendations for future research

In summary, women with a weight below 50kg and/or a height below 145cm and/ or a MUAC smaller than 22cm should be referred for specialised nutritional care during pregnancy. Women who gain less than 1kg per month or more than 3kg per month should be referred to a dietician. Obviously overweight women should also be referred to a dietician and their blood pressure, urinary glucose and indicators of urinary tract infections should be monitored closely.

Studies should be done to assess maternal and foetal health outcomes along the entire spectrum of weight change, in order to clarify whether there are more optimal weight-gain ranges for women in both the general population and sub-populations. Optimal patterns of weight gain over the three trimesters should also be assessed. There is still little documentation on programme experiences to improve prenatal nutrition and weight gain during pregnancy in developing countries (IOM, 1990:1, Dawes *et al.*, 1992:487, Widga & Lewis, 1999:1058, Mora & Nestel, 2000:1353S). Research on optimal energy requirements during pregnancy is also needed, in order to be able to formulate appropriate interventions to improve pregnancy outcomes. Major challenges include lack of general consensus on the

Figure 1 A framework for the management of pregnancy weight gain



interpretation of anthropometric indicators in pregnant women (Theron & Thompson, 1993:269), since these guidelines are recommended as screening tools, rather than for surveillance. The use of anthropometric indicators become more complex in developing countries, such as South Africa, where a large proportion of women are short, but overweight (Puoane *et al.*, 2002:1038) and in developing countries with a high percentage of HIV positive pregnant subjects (Dannhauser *et al.*, 2000:38). Both undernutrition and obesity are public health problems in these countries and both are related to inappropriate weight gain patterns in pregnant women (Theron & Thompson, 1993:269). Longitudinal studies of pregnancy weight gain should be extended beyond delivery to determine if maternal fat reserves are lost in the postpartum period (Eastman & Hellman, 1966:326). Applied research can be especially useful, for example the development of a clinically useful weight gain chart and the evaluation thereof against outcome data (Dawes *et al.*, 1992:487).

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