Studies on energy metabolism and body composition of healthy women before, during and after pregnancy

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Introduction

Current recommendations propose that an entire pregnancy requires an additional amount of energy from the diet equivalent to 335 000 kJ. This figure is mainly based on increases in the basal metabolic rate (BMR) and retention of total body fat (TBF). The BMR response to pregnancy varies considerably among women, but the factors responsible for this variability are unknown. TBF can be calculated from total body water (TBW) and information regarding the hydration of fat-free mass [the hydration factor (HF)] using the two-component model. However, the validity of this model during pregnancy has been questioned since TBW increases by 6-8 kg during gestation. This increase may affect the biological variability of HF, but no studies in this area are available. Furthermore, current recommendations propose that energy needs during pregnancy may be partly offset by reductions in physical activity, but there is little experimental evidence to support this statement.

The aims of this thesis were: to evaluate whether the physical activity level (PAL) can be estimated by means of heart-rate recording, accelerometry or a questionnaire in non-pregnant women; to assess the effect of pregnancy on energy expenditure due to physical activity, on the pattern of physical activity and on the biological variability of HF; to evaluate the use of bioimpedance spectroscopy (BIS) for assessing TBW during pregnancy; and to identify factors explaining the variability in the BMR response to pregnancy.

Material and methods

Thirty-nine healthy, non-smoking women planning pregnancy and living in the Linköping area were recruited between 1998 and 2000 by means of advertisements in the local press and through the healthcare system. The women were employed in the areas of office work, childcare and nursing. All women underwent an investigation before pregnancy. Twenty-three of them became pregnant in time for the study and were also investigated in gestational weeks 8, 14, 20, 32, 35 and 2 weeks postpartum. No pregnant woman was diagnosed with proteinuria, generalized oedema, pre-eclampsia or eclampsia and all 23 women delivered healthy full-term babies. Total energy expenditure was measured by means of the doubly labelled water method and BMR by means of indirect calorimetry. PAL_{ref} was estimated as total energy expenditure/ BMR. In the women planning pregnancy PAL was also estimated by means of a questionnaire (PAL_q) , heart-rate recording (PAL_{HR}) and accelerometer registrations (PAL_{acc}). The pattern of physical activity was assessed using information obtained by means of the questionnaire and heart-rate recording. TBW and extracellular water (ECW) were estimated using BIS as well as isotope dilution and bromide dilution, respectively. Body composition, circulatory variables (heart rate, stroke volume, cardiac output, mean arterial pressure and total peripheral vascular resistance) and serum levels of thyroid hormones and insulin growth factor-I (IGF-I) were measured. HF was calculated as TBW/fat-free mass and its biological variability was estimated by means of a propagation of error analysis. Foetal weight was assessed by means of the ultrasound technique in gestational week 31.

Results and discussion

All estimates of PAL obtained by means of accelerometer recordings, heart-rate recordings and the questionnaire were imprecise and too low in women planning pregnancy (1). The reason for this finding is unknown, but a likely explanation is that the metabolic equivalents (MET factors) for different activities that were used are too low for the relatively heavy and fat subjects in this study.

There was little change in PAL_{ref} in gestational week 14, but it was significantly reduced in gestational week 32 when compared to before pregnancy. However, the pattern of physical activity was largely unaffected by pregnancy (2). The findings support the statement that PAL_{ref} decreases for women who maintain their pre-pregnant physical activity pattern in pregnancy. Thus, for such women the increase in BMR represents the major component of the increased energy expenditure during pregnancy, at least until gestational week 32.

The biological variability in HF was 2%, 3% and 1.7% of average HF before pregnancy and in gestational weeks 14 and 32, respectively (3). These findings support the conclusions that the two-component model for assessing TBF is as appropriate in late gestation as it is in the non-pregnant state, while its precision may be impaired when applied during the first part of pregnancy.

TBW obtained by means of BIS was only slightly lower than TBW measured using isotope dilution in gestational week 14 (4). However, in gestational week 32 BIS underestimated average TBW by as much as 3.75 kg (4). This was mainly due to an underestimation of ECW. The most likely reason for the underestimation of TBW by means of BIS is the model used to calculate body water. This model was developed for the non-pregnant body, which differs in a number of respects from the pregnant body. Thus, BIS in its present form is not useful during pregnancy, especially not in late pregnancy. However, as indicated in Ref. 4 in the thesis, possibilities exist for improving the method.

In gestational weeks 8, 14 and 20, average BMR was similar to the corresponding pre-pregnant value, but in gestational weeks 32 and 35, it was significantly increased by about 30% (5). The BMR response to pregnancy varied considerably between women at all measurements during pregnancy. In gestational week 14, the increase in BMR was significantly correlated with the increase in body weight and percentage of TBF before pregnancy, and together these variables explained almost 50% of the variability in the BMR response (5). In gestational week 32, the increase in BMR was significantly correlated with changes in body weight, TBF, fat-free mass, IGF-I, cardiac output

and free triiodothyronine. At this stage of gestation the increase in body weight, in combination with foetal weight or with the increased levels of IGF-I in serum, explained almost two-thirds of the variability of the increase in BMR (5).

In conclusion: (i) in non-pregnant women estimates of PAL obtained by means of heart-rate recording, accelerometry and the questionnaire were imprecise and too low. This finding is in agreement with previous published results showing that simple methods often produce inaccurate and imprecise PAL estimates; (ii) in women maintaining their pre-pregnant pattern of physical activity the increase in BMR represents the major component of the increased energy expenditure during pregnancy; (iii) the two-component model for assessing TBF is appropriate in late gestation, while its precision may be impaired in early pregnancy; (iv) BIS in its present form is not appropriate for assessing TBW during pregnancy; and (v) nutritional factors are important regarding the variability in the BMR response to pregnancy.

Articles in the thesis

- 1. Löf M, Hannestad U, Forsum E. Comparison of commonly used procedures, including the doubly-labelled water technique, in the estimation of total energy expenditure of women with special reference to the significance of body fatness. Br J Nutr 2003; 90: 961–8.
- 2. Löf M, Forsum E. Activity pattern and energy expenditure due to physical activity before and during pregnancy in healthy Swedish women. 2004. Manuscript.
- 3. Löf M, Forsum E. Hydration of fat-free mass in healthy women with special reference to the effect of pregnancy, Am J Clin Nutr 2004; in press.
- 4. Löf M, Forsum E. Evaluation of bioimpedance spectroscopy for measurements of body water distribution in healthy women before, during and after pregnancy. J Appl Physiol 2004; 96: 967–73.
- Löf M, Olausson H, Boström K, Janerot-Sjöberg B, Sohlström A, Forsum E. Changes in basal metabolic rate during pregnancy in relation to changes in body weight and composition, cardiac output, insulin-growth factor-I, thyroid hormones and foetal growth. 2004. Manuscript.

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