Changes in energy metabolism from pre-pregnancy to postpartum: A case report

Abstract

Purpose: Energy metabolism is at the core of maintaining healthy body weights. Likewise, the assessment of energy needs is essential for providing adequate dietary advice. We explored differences in energy metabolism of a primigravid woman (age: 30y) at 1-month pre-pregnancy ("baseline"), during pregnancy (33 weeks) and at 3 and 9-months postpartum. Measured versus estimated energy expenditure were compared using equations commonly used in clinical practice. **Methods**: Energy metabolism was measured using a state-of-the-art whole body calorimetry unit (WBCU). Body composition (dual-energy X-ray absorptiometry), energy intake (3-day food records), physical activity (Baecke questionnaire), and breastmilk volume/breastfeeding energy expenditure (24-hours of infant test-retest weighing) were assessed. **Results**: This case report is the first to assess energy expenditure in three different stages of woman's life (pre-pregnancy, pregnancy, and postpartum) using WBCU. We noticed that weight and energy needs returned to pre-pregnancy values at 9-months postpartum, although a pattern of altered body composition emerged (higher fat/lean ratio) without changes in physical activity and energy intake. For this woman, current recommendations for energy overestimated actual needs by 350kcal/d (9-months postpartum). **Conclusions**: It is likely that more accurate approaches are needed to estimate energy needs during and post-pregnancy, with targeted interventions to optimize body composition.

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Introduction

The estimation of energy needs during pregnancy and lactation is challenging. Recommendations were derived from high-quality studies but many years ago and based on a limited number of scientific studies [1-6]. It is therefore reasonable to expect that current recommendations for energy may not reflect the needs of contemporary women who generally are older [7], more sedentary and of different body composition [8] compared to data from older studies. This in turn can impact weight gain/retention throughout pregnancy and postpartum.

In an effort to explore the energy needs of these women, we assessed changes in energy expenditure (EE) using a state-of-the-art technique (Whole Body Calorimetry Unit–WBCU) at four timepoints: 1-month pre-pregnancy ("baseline"), pregnancy (33 weeks), and at 3 and 9-months postpartum of a primigravida woman. We also compared measured and estimated EE using common equations.

Presentation of the Case

The unique data presented was acquired as the same individual participated in two unrelated studies, thus allowing the opportunistic investigation of EE changes. Informed consent was obtained according to the University of Alberta Health Research Ethics Board (Pro20408 and Pro42267).

The married, university educated, Caucasian participant was 30y, and working full time prior to maternity leave. Her pre-pregnancy weight and height were 58.06kg and 1.64m, respectively. Resting blood pressure and heart rate were within normal ranges with no adverse health problems. **Table 1**.

Activities undertaken

Total EE (TEE) was measured for 24-hours by indirect calorimetry using a WBCU at all but the 3-month postpartum timepoint – the latter due to exclusive breastfeeding. However, all timepoints included a measure of resting EE (REE). While in the WBCU, individual components of TEE were assessed: REE (30min), exercise EE (35min treadmill walking at 2.5mph and 5% incline, reflective of a low to moderate-intensity walk), and energy expended while pumping breastmilk (five times/day via electric pump). Respiratory Quotient (RQ) was also assessed within the WBCU, and calculated from the ratio of carbon dioxide produced to oxygen consumed by the body.

Body composition was measured by dual energy X-ray absorptiometry (G.E-Medical Systems, Madison-WI, USA, enCORE 9.20 software). Energy intake was assessed using 3-day food records, (ESHA-Food Processor v.10.12.0, Salem-OR, USA), including one weekend and two weekdays, and directed by experienced research staff with extensive nutrition background. Baecke questionnaire [9] was used to assess physical activity, with the following categories: "at work", "sport", and "non-sport leisure" time. Scores for each of these three categories range from one to five and the total physical activity score (sum) range from three to fifteen. A higher score represents a higher level of physical activity.

Exclusively breastfeeding was reported at 3-months postpartum, with both breastmilk and complementary foods given at 9-months. Breastmilk volume was estimated based on 24-hours infant test-retest weighing, in which the infant was weighed before and after each breastfeeding session. Breastmilk volume was used to estimate breastfeeding EE according to the FAO/WHO/UNU Human Energy Requirements report [10], with breastmilk volume corrected for insensible water losses (5%). The energy content of breastmilk was assumed to be 0.67 Kcal/g; and an efficiency factor of 80% was applied.

Mifflin-St Jeor equation [11], commonly used in practice [12], was used to compare measured (WBCU) and estimated REE. Dietary References Intakes (DRIs) [13] and the Factorial Method [14] (using measured and estimated REE and breastfeeding EE) were used to compare measured (WBCU) and estimated TEE. **Table 2**.

Outcomes

Changes in measured TEE and REE are shown in **Figure 1.** REE was similar at baseline, 3 and 9-months postpartum. As expected, REE and TEE increased during pregnancy. Baseline and 9-month TEE were also similar, despite additional energy expended through pumping. While in the WBCU, 410mL of breastmilk was pumped which equated to an estimated energy cost of ~360kcals [10]. Interestingly, according to the WBCU, 1.5kcal/min was expended on average while pumping, totaling 180kcals for five sessions. Fasting RQ was higher at baseline than during pregnancy or postpartum, likely due to underlying metabolic changes or differences in macronutrient intake during those periods. Table 1.

Although body weight returned to pre-pregnancy values at 9-months postpartum, waist circumference was higher compared to pre-pregnancy. No change in lean tissue occurred in the postpartum period, although fat mass increased by 2% (1.5kg) between 3 and 9-months. Energy intake was similar between both postpartum timepoints, and physical activity increased in the postpartum period compared to pregnancy, remaining stable postpartum. Table 1.

Measured REE was higher than estimated at all four timepoints. Minimal differences in measured and estimated TEE were observed at baseline (<100kcal). During pregnancy, measured TEE was lower than predicted by the DRIs [13], and by the two Factorial Methods (measured and estimated). Differences between measured versus predicted TEE were more pronounced at 9-months postpartum, in which the current DRIs recommendations for energy [13] overestimated TEE by 350kcal, **Table 2**.

Discussion

We believe this case report was the first to assess TEE in three stages of woman's life (pre-pregnancy, pregnancy, and postpartum) using WBCU. Although this study carries unique and accurate information, findings are not meant to be generalized due to the intrinsic limitations of a case report.

However, our results highlight the need for further research re-evaluating current recommendations for energy, especially for postpartum women.

Here we reported a woman's TEE returns to pre-pregnancy values by 9-months postpartum, despite additional costs of breastfeeding. Similarly, REE was ~75% of TEE throughout pregnancy and postpartum period, even with significant burden of energy deposition (during pregnancy) and energy stores mobilization (during lactation). It suggests that adaptations in energy metabolism may occur throughout the postpartum period, thus facilitating achievement of pre-pregnancy metabolic state. Likewise, current DRIs recommendations for energy [13] overestimated actual needs for this individual by 350 kcal/d at 9-months postpartum.

Additionally, pumping milk inside the WBCU is different compared to the milk supply-demand cycle of infant feeding. However, our precise WBCU data showed that energy expended in pumping milk was 50% lower than estimated by the FAO/WHO/UNU Human Energy Requirements Report [10]. Likewise, discrepancies between recommended and estimated breastfeeding EE values were observed. As this accounts for ~40% of her TEE, its accuracy should be considered when examining energy requirements. Lactating women are suggested to expend ~400kcal/d during 7-12 months postpartum [13]; however, our estimated value was ~700kcal/d at 9-months postpartum based on 24-hour infant test-retest weighing.

A pattern of altered body composition emerged (higher fat/lean ratio) between 3 and 9-months postpartum without changes in physical activity and energy intake. Therefore, the postpartum period may involve increases in fat mass that are not reflected in overall weight change [15]. Although some women may return to their pre-pregnant weight and EE values, the increase in fat mass and waist circumference may be persistent, with longer-term health effects. Similar to what we observed in this woman, maternal adiposity was not associated with breastmilk volume, after correction for multiple comparisons in another study [16]; however, the impact of breastfeeding patterns on body composition changes should be further investigated. Finally, body composition and more accurate approaches to estimate energy needs may improve nutritional assessment during the postpartum period.

Relevance to Practice

Pregnancy and postpartum energy needs may not be accurately depicted by current equations. Likewise, weight change is not reflective of body composition change. Accurately determining energy needs during these periods is essential for providing adequate dietary advice and promoting a healthy body weight and composition, avoiding any adverse maternal/infant outcomes. Further research is required to re-evaluate and revise current energy recommendations for pregnant and postpartum women.

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Table 1. Descriptive characteristics of anthropometrics, measured energy expenditure and respiratory quotient, body composition, energy intake, breastfeeding, and physical activity, pre-pregnancy, during pregnancy and at three and nine months postpartum.

Participant's characteristics	**Pre-pregnancy**	**Pregnancy (33 weeks)**	**3 months Postpartum**	**9 months Postpartum**
Anthropometrics				
Weight (kg)	58.06	72.00	59.20	57.90
BMI (kg/m^2)	22.2	-	22.1	21.6
Waist circumference (cm)	70.6	-	80.4	76.3
Weight change (kg)[a]	-	-	1.14	-0.16
Blood pressure (diastolic/systolic, mmHg)	104/69	107/68	112/72	107/72
Resting Heart rate (bpm)	63	78	78	74
Measured Energy Expenditure and Respiratory Quotient				
Resting energy expenditure (kcal/day)	1389	1767	1346	1449
Fasting respiratory quotient	0.93	0.83	0.84	0.78
Total energy expenditure (kcal/day)	1847	2226	-	1919
24-hour respiratory quotient	0.90	0.88	-	0.82
Exercise energy expenditure (kcal)	151	191	-	157
Exercise respiratory quotient	0.94	0.93	-	0.87
Body Composition				
Fat mass (kg)	-	-	14.43	15.91
% Fat mass	-	-	24.70	26.74
Lean soft tissue (kg)	-	-	41.66	41.15
Fat-free mass (kg)	-	-	44.09	43.62
Fat:Lean ratio	-	-	0.35	0.39
Energy Intake				
Energy Intake (kcal/day)	-	-	2321	2365
Energy Intake (kcal/kg)	-	-	39	41
Breastfeeding				
24-hours infant test-retest weighing				
Total milk volume expressed (ml/day)	-	-	722	822
Estimated energy expended in breastfeeding (kcal)[b]	-	-	635	723
Energy expended pumping breast milk while in the WBCU				
Total milk volume pumped while in the WBCU (ml/day)	-	-	-	410

Based on the WBCU data points (kcal)	-	-	-	180
Based on the FAO/WHO/UNU Human energy requirements report (kcal)[a]	-	-	-	360
Physical Activity Scores				
Baecke Questionnaire Total	-	7.2	8.5	8.5
Baecke Questionnaire Work	-	2.0	3.1	3.1
Baecke Questionnaire Sports	-	2.5	2.5	2.8
Baecke Questionnaire Leisure	-	2.7	2.9	3.0

BMI: Body Mass Index; WBCU: Whole Body Calorimetry Unit.

[a]Change in weight compared to pre-pregnancy weight.

[b]Based on the FAO/WHO/UNU Human energy requirements report [10].

Energy expenditure and respiratory quotient were measured by indirect calorimetry using a whole body calorimetry unit; Body composition was measured by dual energy X-ray absorptiometry; Energy intake was assessed using 3-day food records; Physical activity was assessed using Baecke Questionnaire [9].

Table 2. Comparison of estimated and measured energy expenditure variables.

Energy Expenditure	Equation	Estimated EE (kcal/day)	Measured EE (kcal/day)	Difference between estimated and measured EE (kcal)
REE				
Mifflin-St Joer [a]	10 x weight (kg) + 6.25 x height (cm) – 5 x age (y) - 161 [b]			
Non-pregnant		1296	1389	-93
Pregnant		1432	1767	-335
3-months postpartum		1302	1346	-44
9-months postpartum		1277	1449	-172
TEE				
DRI [c]				
Non-pregnant	= 354 - (6.91 x age [y]) + PA x {(9.36 x weight [kg]) + (726 x height [m])} [d]	1869	1847	22
Pregnant	= Non-pregnant EER + 272 + 180	2321	2226	95
3-months postpartum	= Non-pregnant EER + 500 - 170	2199	-	N/A
9-months postpartum	= Non-pregnant EER + 400 - 0	2269	1919	350
Factorial Method (measured)				
Non-pregnant	Measured REE x PAL 1.4	1945	1847	98
Pregnant	Measured REE x PAL 1.4 + 452 [e]	2926	2226	700
3-months postpartum	Measured REE x PAL 1.4 + 635 [f]	2519	-	N/A
9-months postpartum	Measured REE x PAL 1.4 + 723 [f]	2752	1919	833
Factorial Method (estimated)				
Non-pregnant	Estimated REE x PAL 1.4	1814	1847	-33
Pregnant	Estimated REE x PAL 1.4 + 272 + 180 [e]	2457	2226	231
3-months postpartum	Estimated REE x PAL 1.4 + 500-170 [g]	2153	-	N/A
9-months postpartum	Estimated REE x PAL 1.4 + 400-0 [g]	2188	1919	269

EE: energy expenditure; REE: resting energy expenditure; TEE: total energy expenditure; DRI: Dietary References Intakes; PA: Physical Activity Coefficient; EER: estimated energy requirements; PAL: physical activity level.

Positive value denotes overestimation by predictive equation. N/A: not available, no comparisons could be made between two data points

[a] Mifflin-St Jeor equation [11]

[b] The same equation was used at all four measurement timepoints

[c] DRI equations [13]

[d] Physical Activity Coefficient of 1 was used in the DRI equations [13], which is consistent with PAL of 1.4 used in Factorial Method. This PAL (1.4) was chosen based on the participant's self-reported physical activity level (lightly active).

[e] Additional pregnant-related calories was estimated based on the DRI equations [13], which takes into account energy expended during pregnancy (272kcal) plus pregnancy energy deposition (180kcal).

[f] Energy expended breastfeeding as measured by breastfeeding diaries and calculated based on the FAO Human energy requirements report [10].

[g] Energy expended breastfeeding as estimated by DRI equations [13] which takes into account milk energy output (three months postpartum: 500kcal, and nine-months postpartum: 400kcal), and weight mobilization (three months postpartum: 170kcal, and nine-months postpartum: zero kcal).

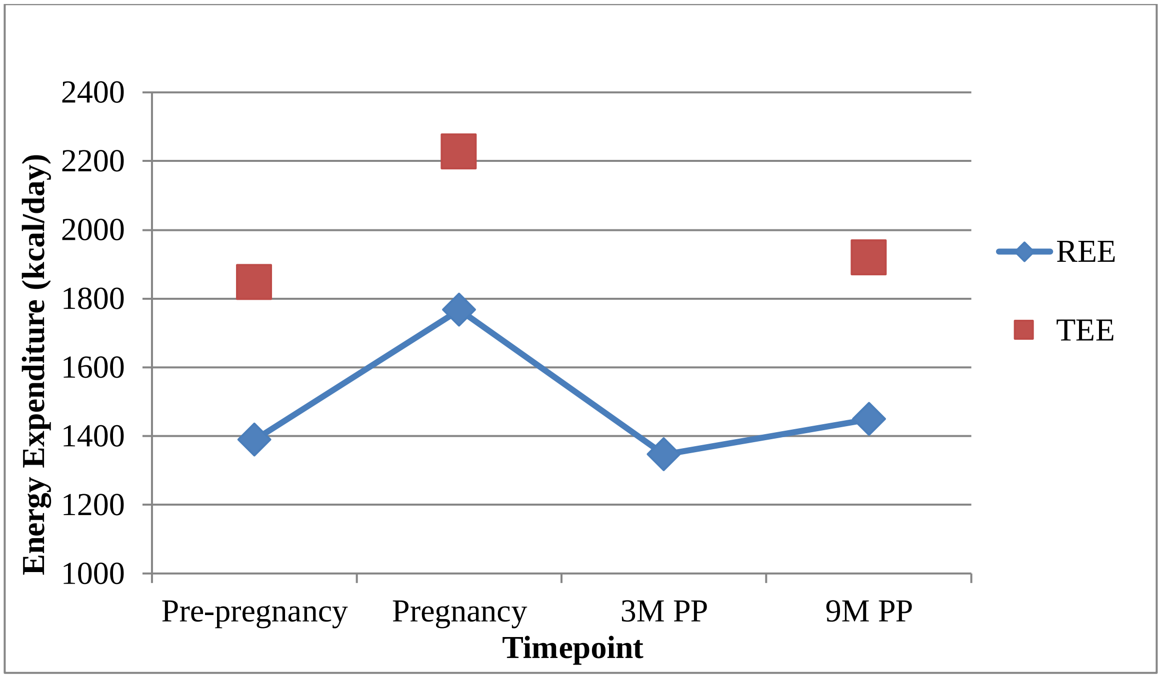

Figure 1. Changes over time in resting and total energy expenditure measured using the whole body calorimetry unit.

REE: resting energy expenditure; TEE: total energy expenditure; 3M PP: three months postpartum; 9M PP: nine months postpartum.