Prospective Changes in Energy Intake, Physical Activity, and Resting Energy Expenditure during Pregnancy

Todd Hagobian, Alyssa D'Amico, Camille Vranna, Anna Brannen, and Suzanne Phelan

Kinesiology Department, California Polytechnic State University

Abstract

Background and Purpose: Prenatal changes in energy intake (EI), physical activity (PA), and resting energy expenditure (REE) are important determinants of future health and obesity outcomes. This study examined changes in EI, PA and REE in 16 adult, pregnant women (75% Normal-weight, 15% overweight/obese) early in pregnancy (<16 weeks), mid-pregnancy (24 weeks) and late-pregnancy (32-weeks). **Results:** From early to mid-pregnancy, women gained an average of 3.7 ± 2.9 kg; EI remained relatively constant (-74 ± 826 kcal/d), PA levels declined by -574 ± 1180 Metabolic Equivalent (METS)*min/wk, and REE increased 122 ± 326 kcal/d. From mid-pregnancy to late-pregnancy, women gained 5.9 ± 2.4 kg; EI increased by 279 ± 352 kcal/d, PA levels increased (460 ± 2000 METS*min/wk) but remained 393 METS*min/wk below early in pregnancy, and REE increased by 251 ± 218 kcal/d. Weight gain trajectories were consistent with IOM recommendations for healthy gestational weight gain (GWG). **Conclusions:** Findings suggest among women with health GWG, a pattern of gradual and relatively small increases in reported EI and REE is expected, with marginal declines in PA throughout pregnancy. Future research with a larger sample size should identify specific caloric and exercise goals associated with healthy GWG and pregnancy health outcomes.

Keywords: Prenatal, resting metabolic rate, exercise, physical activity, energy intake

Introduction

Current pregnancy guidelines recommend that pregnant women increase dietary energy intake by 340 to 450 kcal/d and exercise most, if not all, days of the week (Committee on Obstetric, 2002; Kaiser, Campbell, & Academy Positions Committee, 2014). The increases in dietary energy intake are needed to support adequate gestational weight gain and to meet increases in resting energy expenditure (REE) typically observed in pregnant women (Butte, Wong, Treuth, Ellis, & O'Brian Smith, 2004). Some longitudinal studies have shown that energy intake is higher, and physical activity levels are lower, late in pregnancy compared to early in pregnancy (Renault et al., 2012), but surprisingly, few studies have examined prospective changes in energy intake, physical activity, and REE starting <16 weeks gestation. Understanding these behavior and REE changes during pregnancy will provide insight into the health of both the mother and newborn (Abrams, 1994; Brion et al., 2010). Thus, the purpose of this study was to examine changes in gestational weight gain, energy intake, physical activity, and REE at multiple time points during pregnancy. We hypothesized that compared to early in pregnancy, weight gain, energy intake and REE would be higher, and physical activity levels would be lower at mid-pregnancy and at late-pregnancy. In exploratory analyses,

we examined predictors of REE late in pregnancy.

Methods

Participants

Sixteen, healthy, adult women were recruited early in pregnancy (12-16 weeks gestation) in central California through local radio station advertisements, Internet sites, and flyers at local OB/GYN clinics (Table 1). We chose to enroll women starting at 12 weeks gestation as the risk of spontaneous abortion (miscarriage) is greatly reduced at this gestational age. Eligibility included a body mass index of 18.5 – 39.9 kg/m^2, non-smoking, and English or Spanish speaking. Exclusion criteria included any major medical or psychiatric illness requiring medical monitoring or prohibit physical activity, or extreme diet (e.g. Atkins, Paleo, etc.) that may confound interpretation of results. The Institutional Review Board at California Polytechnic State University approved the study, and all participants provided verbal and written consent.

Table 1.

Participant Characteristics (N=16)

	N	%
Ethnicity		
Non-Hispanic White	13	81%
Hispanic White	3	19%
Married	16	100%
College Educated	12	75%
Weight status		
Normal weight	12	75%
Overweight	1	6%
Obese	3	19%
Gestational weight gain >2009 IOM recommendations assessed at 32-34 weeks gestation		
Normal weight	1	8%
Overweight	1	100%
Obese	2	67%
	Mean	SD
Pre-pregnancy body mass index (self-reported)	25.2	3.6
Age	30.3	3.8

IOM, Institute of Medicine

Measures and Procedures

Measures were conducted early in pregnancy (12-16 weeks gestation), mid-pregnancy (24-26 weeks) and late pregnancy (32-34 weeks), in the morning after an overnight fast. Weight was measured in kg using a standard balance beam scale. Height was measured in meters using a stadiometer. Energy intake was assessed with one, 4-hour dietary recall using the National Cancer Institute Automated 24-hour recall (Subar et al., 2012). Physical activity was measured with the validated International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003). The IPAQ was chosen because it assesses physical activity across a range of activities during pregnancy. REE was measured using a ventilated hood and open-circuit indirect calorimetry to estimate energy requirements, as described in our previous research (Hagobian, Sharoff, & Braun, 2008) consistent with best practice methods of assessing REE (Compher, Frankenfield, Keim, Roth-Yousey, & Evidence Analysis Working, 2006). After 15-20 minutes of relaxation, participants sat comfortably in a reclining chair for 30 minutes, while expired air was connected to an online metabolic system (Parvomedics Truemax 2400, Consentius Technologies, Sandy, UT) (Yeh, 2015) and REE was assessed. The initial five minutes of REE data was discarded or until a steady state was achieved, and the remaining data was averaged.

Statistical Analyses

Data on outcomes of interest were presented as means and standard deviations. A repeated measures analysis of variance was used to determine changes in weight, energy intake, physical activity levels, and REE. Significant differences were defined as $\propto<0.05$. In exploratory analyses, linear regression was conducted to examine behavioral (energy intake, physical activity)

predictors and correlates of REE and gestational weight gain.

Results

As shown in Table 2, significant increases ($p<0.05$) in weight and energy intake, and marginal declines in physical activity ($p=0.06$) were observed from early pregnancy, to 24 weeks gestation and 32 weeks gestation, independent of BMI early in pregnancy (Table 2). Correspondingly, during the same time frame, REE gradually and significantly increased ($p=0.05$) (Table 2). More specifically, from early to mid-pregnancy, women gained an average of 3.7 ± 2.9 kg. Energy intake remained relatively constant (-74 ± 826 kcal/d), physical activity levels declined by -574 ± 1180 Metabolic Equivalent (METS)*min/wk, whereas REE increased 122 ± 326 kcal/d. From mid-pregnancy to late-pregnancy, women gained 5.9 ± 2.4 kg additional. Energy intake increased by 279 ± 352 kcal/d, physical activity levels increased by 460 ± 2000 METS*min/wk (but remained 393 METS*min/wk below early in pregnancy), and REE increased by 251 ± 218 kcal/d. Weight gain trajectories were in line with IOM recommendations for healthy gestational weight gain (GWG) at 32-34 week gestation.

In exploratory analyses, significant predictors of REE at 32 weeks gestation included higher weight at all time points ($p's<0.05$; $\beta=0.68$ early in pregnancy; $\beta=0.64$ at 24 weeks; $\beta=0.69$ at 32 weeks) and higher energy intake early in pregnancy ($p<0.05$; $\beta=0.53$). Physical activity levels did not significantly relate to REE. No significant correlates or predictors of gestational weight gain emerged. Also, no significant interactions with weight group (normal-weight vs. overweight/obese) emerged in any of the analyses, although sample size of overweight/obese was small (N=4).

Table 2.

Weight, Energy Intake, Physical Activity and Resting Energy Expenditure During Pregnancy

Variable	Early (12-16 weeks)	Middle (24-26 weeks)	Late (32-34 weeks)	P (main effect)
	M (SD)	M (SD)	M (SD)	M (SD)
Weight (kg)	70.5 (11.5)	74.1 (12.0)*	80.0 (11.9)$^{\$}$	<0.001
Energy Intake (kcal/d)	2196 (762)	2122 (456)	2401 (591)$^{\$}$	<0.001
Physical Activity (METS*min/wk)	1928 (1826)	1354 (1142)	1535 (1602)	0.061
REE (kcal/d)	1458 (310)	1580 (274)*	1830 (332)$^{\$}$	<0.001

Values are mean (SD).
*Significantly (P<0.05) different than Early Pregnancy.
$^{\$}$Significantly (P<0.05) different than Early Pregnancy and Mid-Pregnancy.
REE, Resting Energy Expenditure; METS, Metabolic Equivalent of Task

Discussion

Few studies have examined repeated measurements of energy intake, physical activity, and REE early in pregnancy, mid-pregnancy, and late-pregnancy. The purpose of this study was to describe changes in gestational weight gain, energy intake, physical activity levels, and REE during pregnancy and to explore relationships among behaviors (diet, physical activity) and REE or gestational weight gain, in a prospective design. The main findings were: 1) significant increases in weight and energy intake, but marginal declines in physical activity were observed from early pregnancy, to mid- and late-pregnancy, and 2) significant predictors of REE at late pregnancy included higher weight at all time points and higher energy intake early in pregnancy, but physical activity was not related to REE.

In general, previous studies have shown that energy intake is higher, and physical activity levels are lower, late in pregnancy relative to early pregnancy (Renault et al., 2012). In the current study, we observed a similar gradual pattern of increased energy intake late in pregnancy but the average increase in energy intake (~200 kcal/d) was noticeably lower than current recommendations (340-450 kcal/d) (Kaiser et al., 2014) and previous assessments of energy balance using doubly-labeled water (Butte et al., 2004). However, these energy intake recommendations are based on increases from pre-pregnancy, and unfortunately, in the current study we did not assess pre-pregnancy energy intake. Nevertheless, the current study is generally consistent with, and extends results of previous studies showing a gradual increase in energy intake during pregnancy using repeat assessments at multiple time points.

Surprisingly, we noted marginal declines in physical activity suggesting that pregnant women are able to maintain activity levels throughout pregnancy regardless of weight status. The lack of major decline in physical activity levels was unexpected given that pregnant women generally decrease physical activity levels throughout pregnancy (Renault et al., 2012). Specifically, physical activity levels appear to decline the most from early in pregnancy to second trimester (which was also noted in the current study), and this decline occurs irrespective of weight status (Daly et al., 2015). There are several explanations as to why we noted marginal declines in physical activity throughout pregnancy. First, in the current study most women were normal-weight, non-Hispanic white, and college educated, all of which is related to higher physical activity levels in pregnancy (Chasan-Taber et al., 2007; Daly et al., 2015). Second, initial assessment of physical activity occurred at 12-16 week gestation, when most women have much less nausea and vomiting and/or are possibly willing to continue previous physical activity now that they have passed the first 8-10 weeks of pregnancy when risks for miscarriage has subsided. Finally, the final assessment of physical activity was at 32-34 weeks gestation rather than later in pregnancy (>35 weeks gestation) when fetal growth and development has increased even more, possibility making physical activity more difficult and uncomfortable.

Previous studies have shown that REE is higher late in pregnancy, compared to early in pregnancy (Butte et al., 2004), which increases energy requirements during pregnancy. In the current study we explored whether weight and behaviors earlier in pregnancy may predict REE late in pregnancy. We found that higher weight early in pregnancy to mid-late gestation was the strongest predictor of higher REE later in pregnancy. Additionally, higher energy intake (~200 kcal/d) early in pregnancy predicted higher REE late in pregnancy, but marginally lower physical activity levels were not related to REE. These data suggest that weight gain is the primary determinant of REE during pregnancy. From a health perspective, understanding determinants of REE, including healthy weight gain, may improve fetal growth and health (Abrams, 1994).

Limitations

There are several limitations to this study. First, because final weight was collected at 32-24 week gestation and not at delivery, we were unable to completely examine whether women exceeded IOM weight gain guidelines, which hinders our ability to determine energy intake and physical activity amounts associated with recommended levels of gestational weight

gain. Also, it is important to note that this was a small sample size; physical activity was self-reported with the IPAQ questionnaire (which may have led to the high variability) and not measured objectively through accelerometry. Finally, results may not be generalizable to the population at-large, as most women in this study were Non-Hispanic White and college educated.

Conclusion

In conclusion, although sample size of this study was limited, findings suggest a pattern of gradual and relatively small increases in reported energy intake and REE, with marginal declines in physical activity throughout pregnancy. The health implication of this pilot study suggests that women are able to continue physical activity during pregnancy and should be supported in doing so. Future research with a larger sample size should identify specific caloric and exercise goals associated with healthy gestational weight gain and pregnancy health outcomes.

References

Abrams, B. (1994). Weight gain and energy intake during pregnancy. *Clinical Obstetrics and Gynecology*, 37(3), 515-527.

Brion, M. J., Ness, A. R., Rogers, I., Emmett, P., Cribb, V., Davey Smith, G., et al. (2010). Maternal macronutrient and energy intakes in pregnancy and offspring intake at 10 y: Exploring parental comparisons and prenatal effects. *American Journal of Clinical Nutrition*, 91(3), 748-756.

Butte, N. F., Wong, W. W., Treuth, M. S., Ellis, K. J., & O'Brian Smith, E. (2004). Energy requirements during pregnancy based on total energy expenditure and energy deposition. *American Journal of Clinical Nutrition*, 79(6), 1078-1087.

Chasan-Taber, L., Schmidt, M. D., Pekow, P., Sternfeld, B., Manson, J., & Markenson, G. (2007). Correlates of physical activity in pregnancy among Latina women. *Maternal and Child Health Journal*, 11(4), 353-363.

Committee on Obstetric, P. (2002). ACOG committee opinion. Exercise during pregnancy and the postpartum period. Number 267, January 2002. *American College of Obstetricians and Gynecologists*. International Journal of Gynecology & Obstetrics, 77(1), 79-81.

Compher, C., Frankenfield, D., Keim, N., Roth-Yousey, L., & Evidence Analysis Working, G. (2006). Best practice methods to apply to measurement of resting metabolic rate in adults: a systematic review. *Journal of the American Dietetic Association*, 106(6), 881-903.

Craig, C. L., Marshall, A. L., Sjostrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., et al. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports & Exercise*, 35(8), 1381-1395.

Daly, N., Mitchell, C., Farren, M., Kennelly, M. M., Hussey, J., & Turner, M. J. (2015). Maternal obesity and physical activity and exercise levels as pregnancy advances: An observational study. *Irish Journal of Medical Sciences*.

Hagobian, T. A., Sharoff, C. G., & Braun, B. (2008). Effects of short-term exercise and energy surplus on hormones related to regulation of energy balance. *Metabolism*, 57(3), 393-398.

Kaiser, L. L., Campbell, C. G., & Academy Positions Committee, W. (2014). Practice paper of the Academy of Nutrition and Dietetics abstract: nutrition and lifestyle for a healthy pregnancy outcome. *Journal of the Academy of Nutrition and Dietetics*, 114(9), 1447.

Renault, K., Norgaard, K., Secher, N. J., Andreasen, K. R., Baldur-Felskov, B., & Nilas, L. (2012). Physical activity during pregnancy in normal-weight and obese women: compliance using pedometer assessment. *Journal of Obstetrics and Gynaecology*, 32(5), 430-433.

Subar, A. F., Kirkpatrick, S. I., Mittl, B., Zimmerman, T. P., Thompson, F. E., Bingley, C., et al. (2012). The Automated Self-Administered 24-hour dietary recall (ASA24): A resource for researchers, clinicians, and educators from the National Cancer Institute. *Journal of the Academy of Nutrition and Dietetics*, 112(8), 1134-1137.

Yeh, P. (2015). True One 2400: Metabolic Measuring System: ParvoMedics, Inc., Sandy, UT.

Author Information
Todd Hagobian, PhD
Kinesiology Department, California Polytechnic State University
1 Grand Avenue
San Luis Obispo, CA 93407
805.756.7511 (ph); 805.756.7273 (fax);
Todd Hagobian: thagobia@calpoly.edu
Alyssa D'Amico: aldamico322@gmail.com
Camille Vranna: camille.vranna@gmail.com
Anna Brannen: acbranne@calpoly.edu
Suzanne Phelan: sphelan@calpoly.edu

* corresponding author