Activity Behaviours in Lean and Morbidly Obese Pregnant Women

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Abstract

Interventions to increase physical activity in pregnancy are challenging for morbidly obese women. Targeting sedentary behaviours may be a suitable alternative to increase energy expenditure. We aimed to determine total energy expenditure, and energy expended in sedentary activities in morbidly obese and lean pregnant women.

We administered the Pregnancy Physical Activity Questionnaire PPAQ (non-objective) and the Actical accelerometer (objective) to morbidly obese (BMI≥40kg/m^2) and lean (BMI≤25Kg/M^2) pregnant women recruited in early (<24 weeks), and late (≥24 weeks) gestation. Data are mean (SD).

Morbidly obese pregnant women reported expending significantly more energy per day in early (n=140 vs 109; 3198.4 (1847.1) vs 1972.3 (10284.8) Kcal/day, p<0.0001) and late (n=104 vs 64; 3078.2 (1356.5) vs 1947.5 (652.0) Kcal/day, p<0.0001) pregnancy, and expended significantly more energy in sedentary activities, in early (816.1 (423.5) vs 540.1 (244.9) Kcal/day, p<0.0001) and late (881.6 (455.4) vs 581.1 (248.5) Kcal/day, p<0.0001) pregnancy, than lean pregnant women. No differences were observed in the proportion of energy expended sedentary between lean and morbidly obese pregnant women.

The greater total energy expenditure in morbidly obese pregnant women was corroborated by Actical accelerometer in early (n=14 per group, obese 1167.7 (313.6) Kcal; lean 781.1 (210.1) Kcal, p<0.05), and in late (n=14 per group, obese 1223.6 (351.5) Kcal; lean 893.7 (175.9) Kcal, p<0.05) pregnancy.

In conclusion, non-objective and objective measures showed morbidly obese pregnant women expended more energy per day than lean pregnant. Further studies are needed to determine whether sedentary behaviours are a suitable target for intervention in morbidly obese pregnancy.

Key words: energy expenditure, lean, morbidly obese, pregnancy.

Background

Among women of reproductive age, obesity (body mass index BMI ≥30kg/m^2) levels have increased in the last decades (1-4). Recent estimates indicate 22% of pregnant women are obese (5), whilst around 2% are severely obese (BMI ≥40kg/m^2) (6).

Obesity in pregnancy is associated with adverse outcomes for mother and offspring (7, 8). Interventions to increase energy expenditure are an option to control weight and gestational weight gain, but these are challenging to implement in morbidly obese pregnant women (9). Indeed previous studies have shown that levels of physical activity are very low among pregnant women (10), particularly amongst those that are overweight/obese compared with normal-weight (11). Overweight individuals expend considerably more calories than normal weight individuals doing the same exercise (12). Obese pregnant women need more energy to move and have a higher metabolic cost than lean pregnant women, so the work of breathing and moving takes a greater effort, and peripheral motor efficiency is decreased (13). Studies comparing physical activity between obese and normal weight pregnant women are very scarce (11), and the majority of interventions based on increasing physical activity levels in obese pregnant women have been largely unsuccessful in preventing adverse pregnancy outcomes (14-16). Targeting a reduction in sedentary behaviours (i.e., activities that expend very low energy, such as sitting or lying or reclining), may be a realistic alternative (17).

Epidemiological studies show that in the general adult population around 55% to 60% of time awake, is spent sedentary (18, 19). In a systematic review, we showed that pregnant women spend more than 50% of their time sedentary (20). A handful of studies suggest increased time in sedentary behaviours during pregnancy is associated with adverse maternal and offspring outcomes. These include higher maternal levels of LDL cholesterol (21), C-reactive protein (21) and gestational diabetes (22), for the

mother, and higher new born abdominal circumference (23), and risk of macrosomia (birthweight>4000g) (24), for the offspring.

As little is known about sedentary behaviours in morbidly obese pregnant women, we aimed to determine total energy expenditure, and energy expended in sedentary activities in morbidly obese and lean pregnant women using two validated methods, objective (Actical accelerometer) and non-objective (PPAQ). We hypothesised that morbidly obese pregnant women would expend less energy in total activities, but proportionally more time in sedentary activities than lean pregnant women.

Methods

Subjects were morbidly obese (BMI≥40kg/m^2) women with a singleton pregnancy attending the Antenatal Metabolic Clinic at the Royal Infirmary of Edinburgh, UK, and lean (BMI ≤25 kg/m^2) pregnant women recruited from community antenatal clinics who were participating in a larger study examining the consequences of morbidly obese pregnancy. Details of the overall cohort have been previously described (25, 26).

Ethical approval was obtained from the Lothian NHS Research Ethics Committee, and all subjects gave informed written consent (REC reference number 08/S1101/39).

In this cross-sectional study women were asked to complete the Pregnancy Physical Activity Questionnaire (PPAQ) in early (<24 weeks' gestation), and late (>24 weeks' gestation) pregnancy. The PPAQ is designed specifically for pregnant women to assess the energy expended in activities of different intensities. It contains 36 questions and was validated against the Actigraph accelerometer (Manufacturing Technology, Inc.) in pregnant women in 2004 (27). Results on energy expenditure are given in metabolic equivalents (28) per day and as total activity plus four different activity levels (sedentary, light, moderate and vigorous). Additionally, energy expenditure is given separately in three type of activities (house activities including caring, occupational, and sports or exercise). To show the data in Kcal per day, we calculated the resting

metabolic rate (RMR) using the Mifflin and St. Jeor equation (29), which has been tested as the best equation to estimate resting energy expenditure in obese and non-obese adults (30, 31).

Energy expenditure was also assessed in early and late pregnancy, in a subset of women (n=14 per group) using the *Actical* accelerometer (Mini Mitter Company, Inc., US), which gives data on Active Energy Expenditure in kilocalories per minute a day, and has been validated for use in healthy adult populations (32). Sedentary activity was classified as time spent performing activities that register less than 100 counts per minute (33). Women wore the device on their non-dominant wrist, for two weekdays and one weekend day, for 24 hours each day (including sleeping time), and were told to remove the Actical only for bathing, or during water sports activities.

Statistical analyses

Data distribution was tested using the Shapiro-Wilk normality test. Continuous variables including time spent in sedentary behaviours, and relative total daily energy expenditure, were compared between morbidly obese and lean pregnant women using T-tests or ANOVA for normally distributed variables and Mann-Whitney U test for data that were not normally distributed. We compared the proportions of energy expended in the different daily activities between groups using ANOVA or Mann-Whitney as appropriate. Regression analyses were used to adjust for potential confounders when analysing the PPAQ. In particular we adjusted for parity and socio-economic status as these have been reported to influence activity levels in other studies (34) and also differed in our sample (supplementary tables 2 and 3). Differences were accepted as significant at $p < 0.05$. Data were analysed using IBM SPSS Statistics 19.0 software.

Results

The PPAQ was completed by 109 lean and 140 morbidly obese women in early pregnancy (<24 weeks, range 12-23 weeks), and 64 lean and 104 morbidly obese women in late pregnancy (⩾24 weeks, range 24-36 weeks).

Table 1 shows the characteristics of participants who completed the PPAQ. Morbidly obese pregnant women had higher BMI, parity, were of lower deprivation category status, were younger, delivered earlier, and gained significantly less weight than lean pregnant women.

Demographics of the women (n=14 lean early; 14 lean late; n=14 morbidly obese early; 14 morbidly obese late) who wore the accelerometer were similar to the full cohort (Supplementary Table 1).

Total Energy Expenditure and Sedentary Energy Expenditure in morbidly obese and lean pregnant women

When comparing reported energy expenditure using the PPAQ between morbidly obese and lean pregnant women, morbidly obese expended significantly more energy per day as total expenditure and in sedentary activities in both early and late pregnancy, as shown in Table 2. These differences remained significant in regression analyses adjusting for maternal age, parity, deprivation status and ethnicity.

Objective measurements of energy expenditure using the Actical confirmed that morbidly obese pregnant women expended significantly more energy than lean pregnant women in early and late pregnancy despite the observation that in both stages of pregnancy morbidly obese pregnant women performed significantly fewer activity counts than lean pregnant women (Table 3).

Proportions of Total Energy Expenditure in different intensity activities

Proportions of energy expended in different intensities of activity are shown in Figure 1 (a-b). In early and late pregnancy, morbidly obese pregnant women expended

significantly more energy in light intensity and significantly less energy in vigorous intensity activities than lean pregnant women. Differences in the proportion of time spent in vigorous activities remained significant after the regression analysis, controlling for maternal age, parity, deprivation status, and ethnicity. Differences in the proportion of time in light intensity activities did not remain significant in adjusted analyses. No differences were observed between lean and morbidly obese pregnant women in the proportion of time spent in moderate or sedentary intensity activities.

Discussion

Our findings demonstrate that morbidly obese pregnant women expend more energy in all physical activities other than vigorous activities than lean pregnant women. This is despite the observation that morbidly obese pregnant women have fewer objectively measured activity 'counts' than lean pregnant women. Further, though both groups spent a similar time in sedentary activities, morbidly obese pregnant women expended more energy when sedentary than lean pregnant women.

Our observation that morbidly obese pregnant women expended significantly less energy in vigorous activities than lean pregnant women corresponds to other studies showing that this domain of physical activity volume is lower among pregnant women (10), but even lower among overweight or obese pregnant women (11). However, we had anticipated that morbidly obese women would spend proportionally more time in sedentary activities than lean women, but objective measures showed time spent sedentary was similar in both groups. The obese group also expended significantly more total energy daily than lean pregnant women in sedentary activities, consistent with their greater basal metabolic rate (30). Though morbidly obese pregnant women expended significantly more total energy than lean pregnant women, they registered significantly fewer activity counts than lean women using the Actical accelerometer. Counts assessed by Actical are an indication of movement in relation to different planes, gravitational forces, magnitude and duration of the sensed acceleration, but

not linked to personal characteristics such as gender, age, or body weight (33). Thus interventions designed to increase overall movement, many of which could be performed whilst sedentary i.e. sitting, lying, or reclining, may still be a suitable target for morbidly obese pregnant women. Our observations were similar in early and late pregnancy suggesting any intervention should be started in early pregnancy.

A strength of the study is that we used two different methods to assess energy expenditure and sedentary behaviours, including the PPAQ questionnaire, which has been validated in pregnancy, and an objective device. Due to the detailed characterisation of the women we were able to adjust for potential confounding factors including parity and socioeconomic status which were associated with differences in energy expenditure in our sample, as has been reported by others (34). Findings remained significant after adjustment for these confounders. Limitations include the risk of recall bias and potential for lack of reliability of the PPAQ, since subjects might be dishonest or inaccurate in their responses. We also acknowledge the small sample size used with the Actical accelerometer limits interpretation of results. Whilst subjects wore the accelerometer for the recommended time of the manufacturer, we acknowledge this was for a relatively short time. Despite this, the Actical findings for energy expenditure were consistent with the PPAQ outcomes. A further strength is the focus on morbidly obese pregnant women, who may be unable to participate in interventions designed for less severely obese women (15, 35), and have also been identified to have specific barriers to participation in physical activity interventions (36). We acknowledge that time spent sleeping, which may impact on the time spent sedentary, was not specifically assessed in our study, but we are not aware that sleep duration differs between morbidly obese and lean pregnant women (37).

Though we used two validated measures to assess physical activity in pregnancy, neither was specifically designed to understand sedentary activities in pregnancy. A

recent systematic review highlighted the heterogeneity in assessment of sedentary activity (20) with measures ranging from 7 to 18 hours per day.

Perspective

A better understanding of sedentary activity is needed for the design of effective interventions to help to reduce the adverse effects of obesity on pregnancy, especially as obesity prevalence is growing among fertile women (38), and that there are risks associated with obesity during pregnancy, for mothers and offspring. We have shown that morbidly obese pregnant women expend significantly more energy than lean pregnant women, but they also expend significantly more energy on sedentary activities. These findings suggest that energy expenditure might not be the key factor to obesity, but energy intake might be. Nevertheless, sports and physical activity interventions may play a role as preventive health factors contributing to better and effective alternatives to reduce those risks associated with obesity during pregnancy, and to reduce time spent sedentary.

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Tables.

Table 1. Characteristics of obese and lean participants who completed the PPAQ in early and late pregnancy.

Characteristic	EARLY			LATE		
	Lean (n=109) Mean (SD) or n (%)	**M. Obese** (n=140) Mean (SD) or n (%)	***p*-value**	**Lean** (n=64) Mean (SD) or n (%)	**M. Obese** (n=104) Mean (SD) or n (%)	***p*-value**
BMI (Kg/m^2)	22.8 (2.7)	44.2 (4.5)	<0.001	22.8 (1.6)	44.1 (5.0)	<0.001
Maternal age (years)	33.06 (4.55)	30.73 (5.40)	<0.001	33.61 (4.45)	31.50 (5.26)	<0.05
Parity			<0.01			<0.01
0	68 (62.4)	64 (46)		41 (64.1)	43 (41)	
1	29 (26.6)	41 (29.5)		16 (25)	38 (36.2)	
2	12 (11)	31 (39)		7 (10.9)	20 (19)	
3	0 (0)	2 (1.4)		0 (0)	2 (1.9)	
4	0 (0)	0 (0)		0 (0)	0 (0)	
5	0 (0)	0 (0)		0 (0)	2 (1.9)	
Ethnicity			>0.05			>0.05
Caucasian	97 (89)	124 (89.2)		54 (84.4)	84 (81)	
Other	0 (0)	4 (2.9)		0 (0)	3 (2.9)	
Deprivation Category			<0.001			<0.01
Low	28 (25.9)	11 (8.0)		15 (24.6)	12 (11.7)	
Middle	79 (73.1)	103 (75.7)		46 (75.4)	79 (76.7)	
High	1 (0.9)	22 (16.2)		34 (0)	12 (11.7)	
Birth weight (g)	3513 (541)	3574 (558)	>0.05	3584 (512)	3511(595)	>0.05
Gestational age at delivery (week)	40.34 (1.34)	39.79 (1.50)	<0.005	40.50 (1.38)	39.68 (1.42)	<0.001
Weight gain (kg)	10.16 (3.64)	5.87 (5.03)	<0.001	10.41 (4.05)	5.59 (5.53)	<0.001

Data are mean (SD) or n (%). Weight gain was calculated as Weight week 36 –weight weight at baseline.
Deprivation Category is based on postcodes.

Table 2. PPAQ comparisons in total and sedentary energy expenditure between lean and morbidly obese pregnant women in early and late stage.

	Early Mean (SD)		**β (95% CI)** †	**Late** Mean (SD)		**β (95% CI)** †
	Lean (n=109)	M.Obese (n=140)		Lean (n=64)	M.Obese (n=104)	
Total EE (Kcal/day)	1972.29 (1028.85)	3198.37 (1847.05)	0.33**(575.73 -1390.80)	1947.54 (652.03)	3078.23 (1356.46)	0.43**(699.87 -1631.39)
Sedentary Activity EE (Kcal/day)	590.13 (244.90)	816.07 (423.51)	0.37**(180.08 -397.11)	581.11 (248.51)	881.65 (455.38)	0.34**(110.69 -360.39)

β is the standardised coefficient.
**Significant at p<0.001
†Adjusted for Maternal Age, Parity, Deprivation Category, and Ethnicity.

Table 3. Actical comparisons in counts, total energy expenditure, and sedentary time between lean and morbidly obese pregnant women in early and late stage.

	Early Mean (SD)			**Late** Mean (SD)		
	Lean (n=14)	M.Obese (n=14)	**Sig**	Lean (n=14)	M.Obese (n=14)	**Sig**
Sedentary time (min/day)	762.40 (104.68)	799.33 (101.80)	p>0.05	740.70 (89.89)	774.15 (124.70)	p>0.05
Total Activity Counts* (per day)	360160.91 (131302.13)	268683.36 (83567.16	p<0.05	357561.03 (94799.09)	266820.25 (97640.51)	p<0.05
Total EE (Kcal/day)	781.06 (210.15)	1167.69 (313.56)	p<0.01	893.72 (175.88)	1223.64 (351.47)	p<0.05

*Counts are markers of movement.

Supplementary Tables.

Supplementary Table 1. Characteristics of Actical accelerometer participants by groups.

Characteristic	Lean Early* (n=14) Mean (SD)	M. Obese Early* (n=14) Mean (SD)	*p*-value	Lean Late† (n=14) Mean (SD)	M. Obese Late† (n=14) Mean (SD)	*p*-value
Maternal Age (years)	31.08 (4.96)	31.43 (5.11)	>0.05	34.62 (4.81)	34.86 (4.19)	>0.05
BMI (Kg/m^2)	23.44 (1.18)	43.65 (2.99)	<0.001	25.81 (2.13)	44.00 (2.69)	<0.001
% Fat mass	30.08 (3.76)	49.26 (1.58)	<0.001	33.09 (3.24)	50.36 (2.23)	<0.001
Parity			>0.05			>0.05
0	9 (64.3)	6 (42.9)		7 (50)	6 (42.9)	
1	4 (28.6)	4 (28.6)		6 (42.9)	3 (21.4)	
2	0 (0)	3 (21.4)		1 (7.0)	2 (14.3)	
3	1 (7.1)	0 (0)		0 (0)	1 (7.1)	
4	0 (0)	1 (7.1)		0 (0)	1 (7.1)	
5	0 (0)	0 (0)		0 (0)	1 (7.1)	
Ethnicity			>0.05			>0.05
1 (Caucasian)	14 (100)	12 (85.71)		14 (100)	12 (85.71)	
2 (40)	0 (0)	2 (14.29)		0 (0)	2 (14.29)	
Deprivation Category			<0.05			<0.05
Low	7 (50)	1 (7.15)		4 (28.6)	0 (0)	
Middle	7 (50)	12 (85.7)		10 (71.4)	11 (78.6)	
High	0 (0)	1 (7.15)		0 (0)	3 (21.4)	
Birthweight (gr)	3844.73 (463.88)	3581.75 (763.34)	>0.05	3910.00 (485.02)	3819.50 (421.38)	>0.05
Weight Gain (Kg)	10.39 (4.92)	5.49 (1.91)	=0.058	12.19 (3.82)	7.44 (6.05)	<0.05
BMR (Kcal/day)	1442.79 (75.20)	1894.21 (97.08)	<0.001	1496.71 (86.79)	1929.57 (106.06)	<0.001

*Early gestation is between 14 and 23 weeks (median 17.93 weeks).
†Late gestation is between 27 and 37 weeks (median 29.36).

Supplementary Table 2. Comparisons on energy expenditure between nulliparous and multiparous pregnant women.

	EARLY Mean (SD)			**LATE** Mean (SD)		
	Nulliparous (n=132)	**Multiparous** (n=117)	***p*-value**	**Nulliparous** (n=84)	**Multiparous** (n=84)	***p*-value**
Total EE (Kcal/day)	2178.16 (1133.9)	3207.14 (1962.1)	<0.001	2367.70 (1218.1)	2927.29 (1254.6)	<0.001
Sed EE (Kcal/day)	762.14 (335.7)	666.43 (406.9)	<0.01	811.03 (474.6)	723.28 (343.7)	>0.05
Light EE (Kcal/day)	688.46 (461.4)	1274.69 (654.0)	<0.001	754.42 (481.8)	1225.42 (561.6)	<0.001
Mod EE (Kcal/day)	695.76 (791.4)	1236.79 (1351.4)	<0.001	780.77 (864.2)	956.04 (810.7)	<0.01
Vig EE (Kcal/day)	30.58 (59.4)	29.34 (67.6)	>0.05	21.62 (49.0)	21.94 (54.4)	>0.05

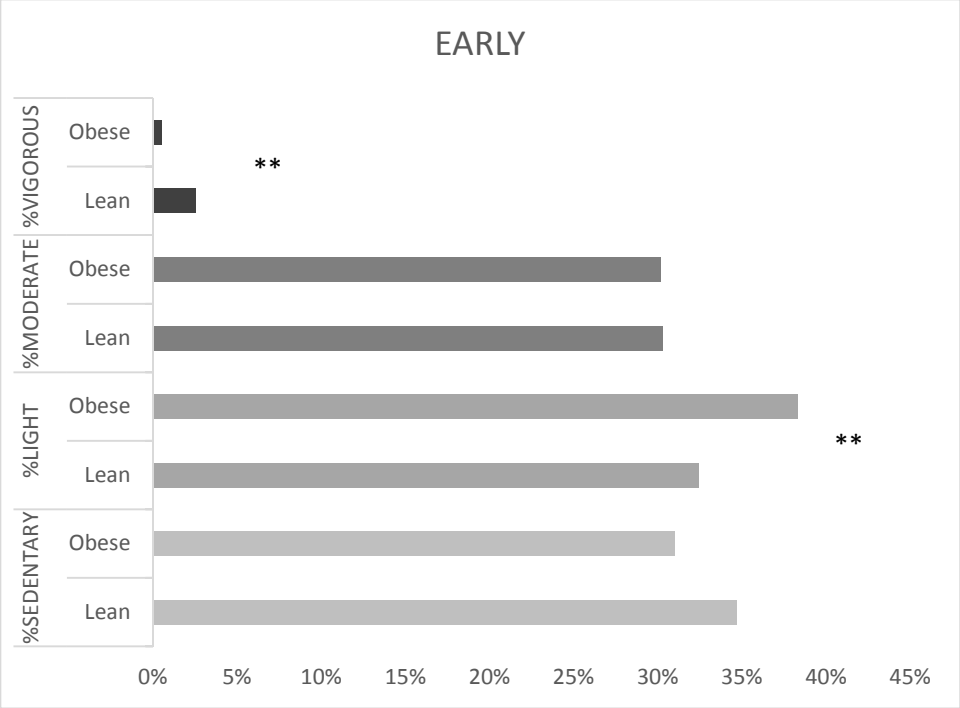
Supplementary Table 3. Comparisons on energy expenditure between most deprived and least deprived pregnant women.

	EARLY Mean (SD)			**LATE** Mean (SD)		
	Most Deprived (n=167)	**Least Deprived** (n=78)	***p*-value**	**Most Deprived** (n=110)	**Least Deprived** (n=53)	***p*-value**
Total EE (Kcal/day)	2531.19 (1608.6)	2844.74 (1598.0)	<0.05	2588.14 (1335.9)	2816.03 (1133.9)	>0.05
Sed EE (Kcal/day)	733.44 (367.9)	689.58 (387.1)	>0.05	769.92 (452.7)	756.66 (336.6)	>0.05
Light EE (Kcal/day)	878.67 (604.6)	1131.62 (654.5)	<0.01	942.24 (572.4)	1106.75 (569.2)	>0.05
Mod EE (Kcal/day)	892.70 (1065.1)	986.13 (1047.2)	>0.05	853.58 (925.4)	932.70 (668.7)	>0.05
Vig EE (Kcal/day)	25.45 (47.3)	37.50 (87.2)	>0.05	22.24 (51.8)	19.49 (49.9)	>0.05

Figures

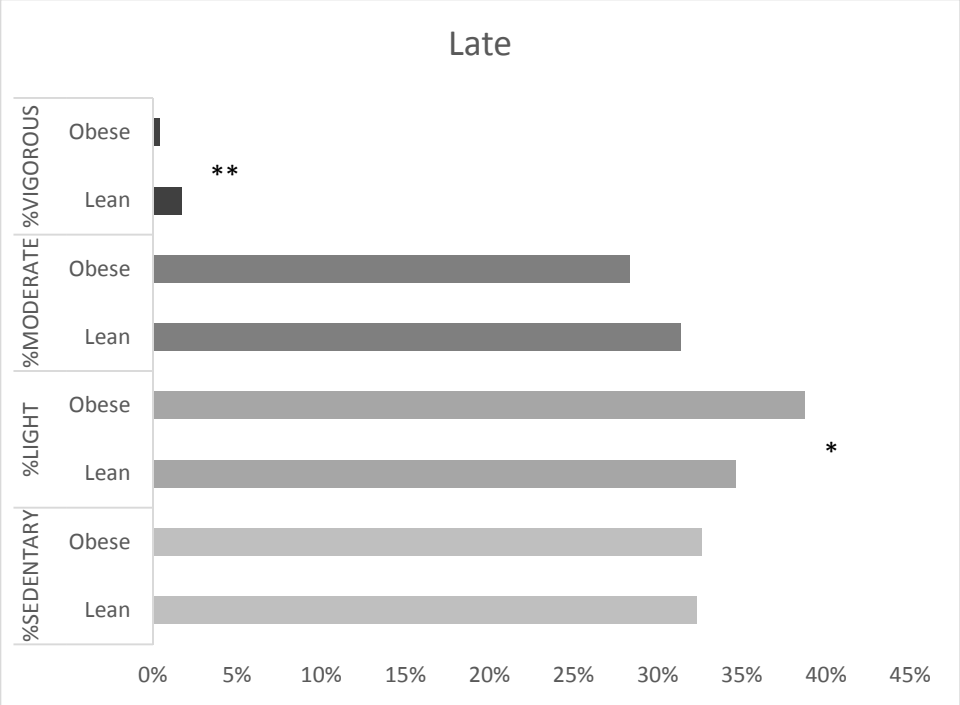
Figure 1.

a) Percentage of self-reported Energy Expenditure per Activity Intensity in early pregnancy.



*Significant at $p<0.05$
**Significant at $p<0.001$

b) Percentage of self-reported Energy Expenditure per Activity Intensity in late pregnancy.



*Significant at p<0.05
**Significant at p<0.001