UPBEAT study:
Association between physical activity in obese pregnant women and health of the offspring

Louise Hayes
on behalf of the UPBEAT Consortium

Note: for non-commercial purposes only
Overview

• Maternal obesity and offspring health
• Physical activity and insulin resistance
• Physical activity, obesity and pregnancy
• Physical activity in UPBEAT
• Physical activity level and off-spring health
• Maternal obesity and weight gain during pregnancy are related to obesity in childhood and adulthood (e.g. Parsons, 1999, *IJO*)
• Macrosomia associated with 2-fold risk of obesity in adulthood (Yu et al, 2011, *Obesity Reviews*)
• Offspring of overweight/obese mothers have worse cardiometabolic profile in adulthood (Hochner et al, 2012, *Circulation*)
• Contribution of intrauterine environment, genes and shared lifestyle
Background

• Role for insulin resistance

• Impact of physical activity on insulin resistance
Obesity, pregnancy and insulin resistance

• Insulin resistance is increased in obese pregnant women compared to normal weight women

Endo et al, Gynecol Endocrinol 2006

* p<0.05
Obesity, pregnancy and insulin resistance

- Insulin resistance is increased in obese pregnant women compared to normal weight women
- Over-nutrition for the fetus and macrosomia
- Impact on offspring development and metabolism in long term
Maternal glucose and childhood obesity

Table 3—Risk ratios for maternal glucose concentration and child BMI ≥85th percentile at 3 years in the PIN Study

<table>
<thead>
<tr>
<th>Glucose concentration (per mg/dL)</th>
<th>Model 1* (n = 263)</th>
<th>Model 2† (n = 256)</th>
<th>Model 3‡ (n = 254)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Risk ratio (95% CI)</td>
<td>P</td>
<td>Risk ratio (95% CI)</td>
</tr>
<tr>
<td>&lt;100 mg/dL</td>
<td>1.01 (1.00–1.02)</td>
<td>0.15</td>
<td>1.01 (1.00–1.02)</td>
</tr>
<tr>
<td>100–&lt;130 mg/dL</td>
<td>Reference</td>
<td></td>
<td>Reference</td>
</tr>
<tr>
<td>≥130 mg/dL</td>
<td>1.00 (0.56–1.78)</td>
<td>1.00</td>
<td>1.04 (0.60–1.81)</td>
</tr>
<tr>
<td></td>
<td>2.15 (1.21–3.84)</td>
<td>0.01</td>
<td>2.34 (1.25–4.38)</td>
</tr>
<tr>
<td></td>
<td>2.48 (1.27–4.82)</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

Risk ratios for maternal glucose concentration are per mg/dL and categories. *Model 1: unadjusted. †Model 2: adjusted for maternal education, race, prenatal smoking, prepregnancy BMI, and maternal height. ‡Model 3: adjusted for Model 2 and birth weight z-score.

Deierlein et al Diabetes Care 2011
GDM, LGA and childhood metabolic syndrome

Fig 1. Prevalence of MS at any age among children grouped according to birth weight and maternal diabetes. Children (n = 175) were divided into 4 groups, ie, LGA with maternal GDM, AGA with maternal GDM, LGA with control (Con) mothers, and AGA with control mothers. MS was defined as the presence of ≥2 of 4 major components (obesity, hypertension, high triglyceride or low HDL levels, glucose intolerance); children were not counted more than once during the 5-year study period. *Overall \( \chi^2 \) group differences, \( P = .008 \); LGA/GDM versus all other groups \( \chi^2, P = .001 \).

Boney et al Pediatrics 2005
Physical activity and insulin resistance

Balkau et al Diabetes 2008

FIG. 1. Mean insulin sensitivity (95% CI) adjusted for age and clinical recruitment center, and characteristics of physical activity measured by accelerometer in men and women according to: mean number of counts/min that the accelerometer was worn (A), by percent sedentary time (B), and by groups according to some moderate and some vigorous intensity activity (C). The ESC study.
Physical activity and insulin resistance

• Good evidence from intervention trials in non-pregnant populations that progression to diabetes can be delayed/prevented if changes in diet and PA achieved

• E.g. DPP, Da Qing, Finnish Diabetes Prevention Study
Mean change in leisure physical activity in DPP (Met hours per week)

Knowler et al. NEJM:2002
Diabetes incidence from baseline in DPP

Reduction in incident diabetes:

**Lifestyle** - 58%

**Metformin** - 31%

Knowler et al. NEJM:2002
Pregnancy, physical activity and insulin resistance

• What evidence that PA during pregnancy reduces insulin resistance?

• Obese pregnant women specifically?
Effect of exercise on blood glucose

Women at high risk of GDM (n=22)

Ruchat et al, *Diabetes Metab Res Rev* 2012
Physical activity and GDM

- Physical activity during pregnancy reduces the risk of GDM

\[
\text{OR} = 1.9 \ (1.2, 3.1)
\]


Physical activity and GDM

**Figure 2**

<table>
<thead>
<tr>
<th>Author (Year)</th>
<th>OR (95% CI)</th>
<th>% Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chasan-Taber (2008)</td>
<td>0.80 (0.20, 2.70)</td>
<td>8.51</td>
</tr>
<tr>
<td>Harizopoulou (2009)</td>
<td>0.13 (0.06, 0.27)</td>
<td>13.9</td>
</tr>
<tr>
<td>Oken (2006)</td>
<td>0.70 (0.30, 1.68)</td>
<td>12.7</td>
</tr>
<tr>
<td>Redden (2010)</td>
<td>0.69 (0.46, 1.03)</td>
<td>18.0</td>
</tr>
<tr>
<td>Rudra (2006a)</td>
<td>0.14 (0.05, 0.38)</td>
<td>11.0</td>
</tr>
<tr>
<td>Rudra (2006b)</td>
<td>0.49 (0.28, 0.87)</td>
<td>16.1</td>
</tr>
<tr>
<td>Zhang (2006)</td>
<td>0.81 (0.68, 1.01)</td>
<td>19.8</td>
</tr>
<tr>
<td><strong>Overall (I²=81.4%, p&lt;0.0001)</strong></td>
<td><strong>0.45 (0.28, 0.75)</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

**NOTE:** Weights are from random effects analysis.

<table>
<thead>
<tr>
<th>Author (Year)</th>
<th>OR (95% CI)</th>
<th>% Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chasan-Taber (2008)</td>
<td>0.80 (0.20, 2.30)</td>
<td>0.45</td>
</tr>
<tr>
<td>Dempsey (2004a)</td>
<td>0.51 (0.27, 0.97)</td>
<td>1.66</td>
</tr>
<tr>
<td>Dempsey (2004b)</td>
<td>0.67 (0.31, 1.43)</td>
<td>1.16</td>
</tr>
<tr>
<td>Harizopoulou (2009)</td>
<td>0.77 (0.71, 0.84)</td>
<td>95.9</td>
</tr>
<tr>
<td>Oken (2006)</td>
<td>0.91 (0.37, 2.21)</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>Overall (I²=0.0%, p=0.77)</strong></td>
<td><strong>0.76 (0.70, 0.83)</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

**NOTE:** Weights are from random effects analysis.

Tobias et al *Diabetes Care* 2011
Physical activity and infant body composition

Pomeroy et al, *Diabetes Care*, 2013

- 30 pregnant women
- OGTT and objective PA measurement at 28-32 weeks
- Infant body composition measured at 11-19 weeks postpartum
- PA associated (negatively) with insulin response ($r = -0.41$, $p = 0.027$) and (positively) with infant fat free mass ($0.52$, $[0.17, 0.74]$)
Physical activity in pregnancy – in the past

• Much of 20th century women advised to avoid exercise when pregnant
  Women who exercise ‘temperamentally unsound’

• By 1985 ACOG guidelines
  • - HR <140bpm
  • - Max 15 mins
  • - No weight lifting

  ‘pregnant women should stringently limit the type, duration and intensity of their exercise to minimize both fetal and maternal risk’
Current guidance - RCOG

• All women should be encouraged to participate in aerobic and strength-conditioning exercise during pregnancy

• Goal = maintenance of fitness level

• Choose activities that minimise risk

• Advise women that adverse pregnancy or neonatal outcomes are not increased by exercise

Source: RCOG Statement No 4
Guidance for obese pregnant women

• NICE
  – Explain risk of being obese and pregnancy
  – Explain that pregnancy not time for weight loss
  – Moderate PA will not harm mother or unborn child
  – 30 mins moderate PA per day
  – Be specific
  – Previously sedentary – 15 mins, 3 times per week
  – Importance of non being sedentary – be active in daily life
  – Offer referral to appropriately trained professional for advice
  – Encourage weight loss after pregnancy
Physical activity levels during pregnancy

• In general been reported that activity declines as pregnancy progresses

• Harrison et al 2012, *BJOG*
  97 women at high risk GDM, mean BMI 30.3, steps per day fell by 1340 (606, 2074) between 12 and 28 weeks’ gestation

• Renault et al 2010, *Acta Obs Gyn Scand*
  338 women (163 BMI 30+)
  steps per day fell by 1856 (obese women) between 12 and 36 weeks’ gestation
  (smaller reduction in normal weight – 1269 steps)
Physical activity in pregnancy - interventions

• Generally PA interventions to improve pregnancy outcomes have been unsuccessful (e.g. Oostdam FitFor2)

• Conclusion of recent (2012) systematic review of lifestyle interventions in pregnancy (Thangaratinam et al, *BMJ*):
  ‘interventions....based on diet are the most effective and are associated with reductions in maternal gestational weight gain and improved obstetric outcomes’
Successful PA interventions

• Ong et al 2009 – *Diab Metabol*
  – 12 sedentary obese women randomised to supervised PA (X3 per week) or control
  – those in intervention group had lower (p=0.07) blood glucose at 28 weeks than those in the control group

• Barakat et al 2011 – *Brit J Spor Med*
  – 80 sedentary women randomised to supervised PA (X3 per week) or control
  – those in intervention group had significantly lower blood glucose at 28 weeks than those in the control group
UPBEAT
UK Pregnancies Better Eating and Activity Trial
• Combined lifestyle intervention

• Aim: to improve glucose homeostasis in obese pregnant women
  – reduce dietary glycaemic load
  – increase physical activity

• Pilot trial completed: March 2010 - May 2011
  Newcastle, London, Glasgow
pilot RCT

• Women recruited by research midwives

• Inclusion criteria: BMI $\geq 30$ kg/m$^2$, singleton pregnancy, gestation 15$^{+0}$ to 17$^{+6}$

• Randomised to intervention or control (standard care)
  – Standard care: appointment with study midwife at 28 weeks’ and 35 weeks’ gestation
**UPBEAT intervention**

- Underpinned by psychological theory (control theory and social cognitive theory)
  - Graded, SMART goals, self-monitoring, provision of feedback, problem solving of barriers, social support and social comparison

- Baseline (~17 weeks’ gestation): one-to-one visit with health trainer

- Weekly group sessions with HT (8 weeks)
  - Dietary advice – consumption of low GI foods, reduction of saturated fats
  - PA advice – increase daily steps walked incrementally, monitored by pedometer

- Data collection by study midwife at 28 and 35 weeks’ gestation
• Outcomes for pilot trial:
  – Diet: GI, GL and energy from SFA
  – PA: MVPA (mins per day, assessed objectively)

• Diet – 24 hour recall and short FFQ

• PA – objectively by Actigraph accelerometer and self-report (modified RPAQ)
Participants

• 183 obese pregnant women recruited (666 eligible invited – 27% response)
  • mean BMI 36.3kg/m²
  • mean age 30.5 years
  • 56% white; 38% black
  • 56% multips
  • 29 women (15.8%) lost to follow-up
### Self-report PA outcomes

<table>
<thead>
<tr>
<th></th>
<th>Baseline (n=159)</th>
<th>28 weeks (n=109)</th>
<th>35 weeks (n=89)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sedentary</strong>†</td>
<td>1008 (197)</td>
<td>1050 (198)</td>
<td>1118 (189)</td>
</tr>
<tr>
<td><strong>Active</strong>†</td>
<td>412 (184)</td>
<td>382 (193)</td>
<td>306 (189)</td>
</tr>
<tr>
<td><strong>Light activity</strong>†</td>
<td>355 (172)</td>
<td>332 (183)</td>
<td>259 (165)</td>
</tr>
<tr>
<td><strong>MVPA</strong>*</td>
<td><strong>57 (93)</strong></td>
<td><strong>51 (67)</strong></td>
<td><strong>47 (78)</strong></td>
</tr>
</tbody>
</table>

Figures are mean minutes (SD) per day

* Significant difference between baseline and 28 weeks
† Significant difference between 28 and 35 weeks
<table>
<thead>
<tr>
<th></th>
<th>Baseline (n=133)</th>
<th>28 weeks (n=75)</th>
<th>35 weeks (n=54)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sedentary</strong>*</td>
<td>592 (133)</td>
<td>588 (117)</td>
<td>572 (98)</td>
</tr>
<tr>
<td><strong>Active</strong>*</td>
<td>221 (61)</td>
<td>202 (75)</td>
<td>203 (64)</td>
</tr>
<tr>
<td><strong>Light activity</strong>*</td>
<td>181 (52)</td>
<td>168 (72)</td>
<td>176 (58)</td>
</tr>
<tr>
<td><strong>MVPA†</strong></td>
<td>41 (20)</td>
<td>34 (17)</td>
<td>27 (15)</td>
</tr>
</tbody>
</table>

Figures are mean minutes (SD) per day

* Significant difference between baseline and 28 weeks
† Significant difference between 28 and 35 weeks
### Self-report PA outcomes

<table>
<thead>
<tr>
<th>Activity</th>
<th>Control (n=54)</th>
<th>Intervention (n=56)</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary</td>
<td>1068 (177)</td>
<td>1020 (226)</td>
<td>-50 (-115,16)</td>
</tr>
<tr>
<td>Active</td>
<td>367 (175)</td>
<td>410 (219)</td>
<td>45 (-16, 106)</td>
</tr>
<tr>
<td>Light activity</td>
<td>333 (165)</td>
<td>340 (204)</td>
<td>11 (-46, 68)</td>
</tr>
<tr>
<td>MVPA</td>
<td>34 (52)</td>
<td>70 (78)</td>
<td>34 (9, 59)</td>
</tr>
</tbody>
</table>

Figures are mean minutes (SD) per day
Differences are adjusted for baseline activity

Poston et al *BMC Preg & Childbirth* 2013
### Objective PA outcomes

<table>
<thead>
<tr>
<th></th>
<th>Control (n=39)</th>
<th>Intervention (n=36)</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary</td>
<td>1175 (86)</td>
<td>1197 (77)</td>
<td>21 (-13, 55)</td>
</tr>
<tr>
<td>Active</td>
<td>209 (82)</td>
<td>194 (68)</td>
<td>-11 (-42, 19)</td>
</tr>
<tr>
<td>Light activity</td>
<td>175 (81)</td>
<td>161 (61)</td>
<td>-9 (-38, 19)</td>
</tr>
<tr>
<td>MVPA</td>
<td>34 (18)</td>
<td>33 (15)</td>
<td>-1 (-9, 5)</td>
</tr>
</tbody>
</table>

Figures are mean minutes per day
Differences are adjusted for baseline activity

Poston et al *BMC Preg & Childbirth* 2013
- Conclusions

• Following intervention
  – Self-reported MVPA was higher
  – Objectively measured MVPA was the same
  – Agreement between accelerometer and RPAQ was very poor (at 28 weeks, $r = -0.069 \ [-0.296 \ to \ 0.165]$)
  – Very difficult to intervene to increase/maintain PA in obese pregnant women
### PA and offspring health

Objectively measured PA and newborn abdominal circumference

<table>
<thead>
<tr>
<th></th>
<th>Baseline (n=61)</th>
<th>28 weeks (n=43)</th>
<th>35 weeks (n=34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary (mins/d)</td>
<td><strong>-0.287</strong>*</td>
<td>-0.92</td>
<td><strong>0.435</strong>*</td>
</tr>
<tr>
<td>MVPA (mins/d)</td>
<td>-0.101</td>
<td>-0.011</td>
<td><strong>-0.466</strong>*</td>
</tr>
</tbody>
</table>

Figures are Pearson correlations
Conclusions

• Danger of concluding that PA unrelated to outcomes in pregnancy – rather than failure of intervention to increase PA level
• Evidence that more active women have improved glucose metabolism
• Evidence that PA associated with favourable offspring health in obese pregnancy
• Difficulty of supporting obese women to be sufficiently active during pregnancy
• More work needed around supporting obese pregnant women to achieve appropriate level of PA – an appropriate target for intervention
• Potential to impact on health of future generations
Many thanks to all the staff and participants in **UPBEAT**

**UPBEAT** is provided by National Institute for Health Research (NIHR) (UK) under the Programme Grants for Applied Research programme RP-0407-10452
Thank you!
Resources


# When not to exercise in pregnancy

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cause of Concern</th>
<th>Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac disease</td>
<td>Severe anaemia</td>
<td>Vaginal bleeding</td>
</tr>
<tr>
<td>Restrictive lung disease</td>
<td>Unevaluated arrhythmia</td>
<td>Dizziness</td>
</tr>
<tr>
<td>Incompetent cervix</td>
<td>Chronic bronchitis</td>
<td>Excess shortness of breath</td>
</tr>
<tr>
<td>Multiple gestation at risk of premature labour</td>
<td>Poorly controlled DM, HT, seizures, hypothyroidism</td>
<td>Headache, chest pain</td>
</tr>
<tr>
<td>Persistent bleeding</td>
<td><strong>Morbid obesity (BMI 40+)</strong></td>
<td>Muscle weakness</td>
</tr>
<tr>
<td>Placenta previa (&gt; 26 wks)</td>
<td>Extreme underweight</td>
<td>Calf pain or swelling</td>
</tr>
<tr>
<td>Premature labour</td>
<td>IUGR</td>
<td>Preterm labour</td>
</tr>
<tr>
<td>Ruptured membranes</td>
<td>Extremely sedentary</td>
<td>Decreased foetal movement</td>
</tr>
<tr>
<td>Preeclampsia/HT</td>
<td>Heavy smoker</td>
<td>Amniotic fluid leakage</td>
</tr>
</tbody>
</table>

*Taken from ACOG guidelines*
Resources

Resources

Resources

Resources

References


• HAPO study