The link between maternal health behaviours and downstream child health

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Objectives

• Intergenerational cycle of obesity

• Risks of maternal obesity & excessive gestational weight gain

• Contributors to healthy pregnancy weight gain

• Strategies to minimize health risk to mom, baby and future
Is there a more important developmental period?
“Life in the womb will be written on your tomb”

**Developmental Programming** identifies how adverse environmental factors operating *in utero* may program or *‘affect’* susceptibility to downstream diseases, our appetite and metabolism, as well as our intelligence and temperament.
2 important maternal contributors to future obesity and cardiometabolic risk

1) Entering pregnancy with a high BMI

Risks associated with overweight/obese pregnancy

- Early Pregnancy:
  - Increased Risk: 0
  - Conditions: Spina bifida, Hydrocephaly, Neural tube defects, Lower IVF success, Miscarriage, Cleft lip, CV anomalies

- Late Pregnancy:
  - Increased Risk: 2
  - Conditions: Gestational hypertension, Fetal death, Pre-eclampsia, UTI, Thromboembolism, Gall bladder disease

- Peripartum & Neonate:
  - Increased Risk: 4+
  - Conditions: Gestational diabetes, Anaesthetic complications, Wound infection, EARLY NEONATAL DEATH, SHOULDER DYSTOCIA, MACROSOMIA, CHILD OBESITY, 3rd-4th degree tearing, Cervical dystocia, Vaginal birth failure, Instrumental delivery/c-section, Post partum thromboembolism, Hemorrhage

Intergenerational cycles

2 important maternal contributors to future obesity and cardiometabolic risk

1) Entering pregnancy with a high BMI

2) Gaining too much weight during pregnancy

What constitutes too much gestational weight gain? (IOM 2009)

<table>
<thead>
<tr>
<th>BMI</th>
<th>Weight (kg)</th>
<th>Recommended Weight Gain</th>
<th>Rates of Weight Gain per week in 2nd and 3rd trimester*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight &lt; 18.5 kg/m²</td>
<td>28-40 lbs (12.5-18 kg)</td>
<td>1 pound 0.51 kilograms</td>
<td></td>
</tr>
<tr>
<td>Normal Weight: 18.5 -24.9 kg/m²</td>
<td>25-35 lbs (11.5-16 kg)</td>
<td>1 pound 0.42 kilograms</td>
<td></td>
</tr>
<tr>
<td>Overweight: 25.0-29.9 kg/m²</td>
<td>15-25 lbs (7-11.5 kg)</td>
<td>0.6 pounds 0.28 kilograms</td>
<td></td>
</tr>
<tr>
<td>Obese ≥ 30.0 kg/m²</td>
<td>11-20 lbs (5-9 kg)</td>
<td>0.5 pounds 0.22 kilograms</td>
<td></td>
</tr>
</tbody>
</table>
Biologic Importance of Weight Gain

But... if a woman is already carrying an extra 20+ kg of fat is this still necessary?

Perils of Gestational Weight Gain - potential mechanism?

If the SC stocks are already full, the spill over into other stores could be detrimental. Known to contribute to BIG babies...

Adapted from Huda et al. 2010
Why are we worried about Birth Weight?
Because of subsequent risk of obesity...

Yu, Obesity Reviews; 2011
GWG and SGA, LGA/macrosomia

As GWG increases so too does the proportion of neonates born LGA or macrosomic regardless of obesity class.

The lowest absolute risk of developing pre-eclampsia, caesarean birth, and infant size being either SGA or LGA for women with BMI > 40 was after a weight loss of zero to 4.1 kg.

Hinkle et al., AJCN; 2010
Why is this Important?

- 60% of Ontario women exceed pregnancy weight gain guidelines

Likelihood of having a Big Baby

*controlling for gestational age, smoking, parity, maternal age

Odds of Macrosomia – Double trouble...

Likelihood of having an LGA baby

Odds ratio

Reference to Normal weight pre-pregnancy and meeting 2009 IOM Guidelines

*controlled for gestational age, smoking, parity, maternal age

Stricter guidelines for overweight/obese women?

- Are the weight gain targets too high for overweight and obese women?

- Do weight gain guidelines take postpartum weight retention seriously enough?

- Should weight gain guidelines take into account the severity of obesity (i.e. class I, II and III obesity)?

- Do these guidelines apply to women with GDM?
Population Attributable Fraction to LGA birth

- White: 33.4%
- Black: 36.8%
- Hispanic: 33.3%
- Asian/Pacific Islander: 37.7%

Kim et al. Obstet Gynecol, 2014
Excessive GWG in normal weight women is associated with increased neonatal adiposity

<table>
<thead>
<tr>
<th></th>
<th>Weight gain within guidelines (N=27)</th>
<th>Excessive weight gain (N=11)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational age</td>
<td>39.8 ± 1.0</td>
<td>40.0 ± 1.2</td>
<td>NS</td>
</tr>
<tr>
<td>Gender (% female)</td>
<td>64%</td>
<td>67%</td>
<td>NS</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>3389 ± 387</td>
<td>3832 ± 552</td>
<td>0.029</td>
</tr>
<tr>
<td>Pea pod weight (g)</td>
<td>3250 ± 370</td>
<td>3700 ± 580</td>
<td>0.028</td>
</tr>
<tr>
<td>Length (cm)</td>
<td>50.1 ± 1.6</td>
<td>51.7 ± 2.4</td>
<td>0.026</td>
</tr>
<tr>
<td>Fat mass (g)</td>
<td>348 ± 103</td>
<td>525 ± 178</td>
<td>0.009</td>
</tr>
<tr>
<td>Fat-free mass (g)</td>
<td>2898 ± 327</td>
<td>3174 ± 415</td>
<td>NS</td>
</tr>
<tr>
<td>Body fat %</td>
<td>10.7 ± 2.8</td>
<td>13.9 ± 3.3</td>
<td>0.012</td>
</tr>
<tr>
<td>Abdominal circumference (cm)</td>
<td>29.9 ± 2.3</td>
<td>31.2 ± 2.3</td>
<td>NS</td>
</tr>
<tr>
<td>Neonatal cord blood</td>
<td>N = 25</td>
<td>N = 10</td>
<td>NS</td>
</tr>
<tr>
<td>Glucose (mg dL⁻¹)</td>
<td>78.0 ± 17.8</td>
<td>87.3 ± 28.4</td>
<td>NS</td>
</tr>
<tr>
<td>C-peptide (ng mL⁻¹)</td>
<td>0.83 ± 0.32</td>
<td>1.0 ± 0.33</td>
<td>NS</td>
</tr>
<tr>
<td>Leptin (ng mL⁻¹)</td>
<td>8.2 ± 4.9</td>
<td>13.4 ± 6.8</td>
<td>0.046</td>
</tr>
<tr>
<td>Adiponectin (µg mL⁻¹)</td>
<td>35.5 ± 5.0</td>
<td>38.1 ± 9.1</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Data are displayed as mean ± standard deviation or percent. NS, not significant.*

Josefson et al, 2012 *Pediatric Obesity*
Why is this Important?

- GWG in excess of guidelines, regardless of pre-pregnancy BMI, is predictive of delivering a large baby.

Excessive GWG increases risk of child overweight by 30%

Nehring et al, *Pediatric Obesity* 2012
GWG was positively associated with offspring BMI-z at all ages even after adjusting for multiple confounders.

*Adjusted for sex, maternal age, pre-gravid BMI, SES, education, smoking etc.
GWG and Childhood overweight/obesity by pre-pregnancy BMI

GWG may be even more important in women with ‘normal’ pre-gravid BMI

Sridhar, AJOG 2014
Why is this Important?

- Pre-eclampsia, GDM
- Fetal macrosomia
- c-section
- Breastfeeding ↓
- Fetal adiposity
- Perinatal morbidity
- Post partum weight retention & obesity
- Downstream obesity & cardiometabolic complications

Adamo et al., Can J Diab 2012
Intergenerational and Maternal cycle of obesity

Excessive GWG increases the risk of child overweight/obesity by 30-40%  Mamun 2013, Nehring 2012

Weight-related issues now exceed smoking as the lifestyle-related risk factor causing greatest number of adverse pregnancy outcomes  Lawlor 2012

To recap...

Why focus on excessive GWG and not pre-gravid BMI?

- It is **realistic**.

- It is highly **prevalent**. Average GWG has increased dramatically over the last four decades around the world.

- Excessive GWG can **exacerbate a woman’s lifelong struggle with weight** and contribute to the intergenerational cycle of obesity.

- GWG is **modifiable**.
Potential Mechanisms?

Potential Epigenetic Modifications to Vital Regulatory Processes
- Early Life Developmental Disruption
- Intergenerational Obesity Transmission
- Chronic Disease Risk

Pre-Natal
- Maternal/Paternal Genotype
- Environmental Factors
- Maternal & Neonatal Phenotype
- Potential Modifiable Lifestyle Factors
  - Healthy Eating
    - Macronutrient balance
    - Cardiometabolic risk
    - Satiety
    - Energy balance
  - Physical Activity
    - Fitness
    - Improved body composition
    - Disease risk
    - Energy balance

Ante-Natal
- Size / morphology
- Blood flow / oxygenation / perfusion balance
- Fat / Carbohydrate / Protein Transport
- Overnutrition
- Hormone production
  - insulin / cortisol
- Growth factor production
  - IGF, EGF, etc.
- Cytokine production
  - leptin / adiponectin
  - TNFα / IL-6
- Metabolism

Birth Phenotype
- Birth weight
- Body composition
- Metabolism
- e.g. insulin resistance
- Systems Development
  - Adipose tissue
  - Liver
  - Skeletal muscle
  - Brain
  - Pancreas
  - Heart
The association between pregnancy weight gain and birthweight: a within-family comparison.

Maternal obesity influences birthweight but paternal obesity does not. (Knight, 2010)
If genetics is the alphabet of life....
  • Letters of DNA sequence carry the information

**EPIGENETICS** is the grammar of life!!!
  • Markings can modify the message
Potential Mechanisms?

- Maternal/Paternal Genotype
- Maternal & Neonatal Phenotype
- Environmental Factors

- Birth Phenotype
  - Birth weight
  - Body composition
  - Metabolism
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- Physical Activity
  - Fitness
  - Improved body composition
  - Disease risk
  - Energy balance
So what can we do?
The Maternal Obesity Management (MOM) Trial Protocol: A lifestyle intervention during pregnancy to minimize downstream obesity

Kristi B. Adamo a,c,f,*, Zachary M. Ferraro a, Gary Goldfield a,c,f, Erin Keely e,h, Dawn Stacey d,i, Stasia Hadjiyannakis a,f,g, Sonia Jean-Philippe a, Mark Walker e,i, Nicholas J. Barrowman b

Contemporary Clinical Trials 35 (2013) 87–96
MOM Trial Objectives

- To evaluate the effects of a structured physical activity and nutritional intervention offered during the 2\textsuperscript{nd} and 3\textsuperscript{rd} trimester of pregnancy on:

**Primary Outcome**
- infant/child body composition @ 24 months

**Secondary Outcomes**
- Gestational weight gain
- Offspring birthweight and weight gain trajectory
- post partum weight retention
- pregnancy related complications (GDM, pre-eclampsia, c-section etc.)
- Psychosocial functioning (stress, social support, depression, attitudes)
- maternal biomarkers (surrogate of intrauterine envir.)
- maternal PA and dietary habits
- Infant feeding and activity patterns
Assessed for eligibility (n=127)

- Excluded (n=51)
  - Not meeting inclusion criteria (n=12)
  - Declined to participate (n=10)
  - Other reasons (n=9)
  - No show to V1 (n=4)
  - Never replied/could not be reached (n=10)
  - No time in schedule (n=6)

Randomized (n=76)

Enrolment

Allocated to intervention (n=41; N=7, OW=13, OB=21)
- Received allocated intervention (n=31, N=7, OW=9, OB=15)
- Loss-to-follow-up (n=5, N=0, OW=3, OB=2)
- Dropped out/did not continue to participate (n=5, N=0, OW=3, OB=2)

Allocated to Control (n=35; N=6, OW=15, OB=14)
- Participated in the trial (n=19, N=5, OW=8, OB=6)
- Loss-to-follow-up (n=10, N=1, OW=4, OB=5)
- Dropped out/did not continue to participate (n=6, N=0, OW=3, OB=3)

Follow up

Completed the trial (n=11, N=0, OW=5, OB=6)
- Dropped out (n=1, N=0, OW=0, OB=1)
- Loss to follow up (n=3, N=1, OW=1, OB=1)

Completed the trial (n=3, N=0, OW=2, OB=1)
- Dropped out (n=2, N=0, OW=0, OB=2)
- Loss to follow up (n=4, N=0, OW=4, OB=0)
MOM Time line: Pregnancy Intervention period

2nd trimester

Screening 12-20 wks V1
M4 Consent Form Demographics Weight/height Blood Sample Food record (7 days) Questionnaires Actical (7 days) PA recall (7 days)

26-28 wks V2
M6 Food record (7 days) Blood sample/GTT Weight/height Questionnaires Actical (7 days) PA recall (7 days)

3rd trimester

36-40 wks V3
M8 Food record (7 days) Blood sample Weight/height Questionnaires Actical (7 days) PA recall (7 days)

M9 Delivery Cord blood and placenta coll.

Post-delivery

Antenatal charts/medical records Mom and offspring follow-up 3, 6, 12, 24 months

REE Dietitian visit
MOM Healthy Pregnancy handbook

Nutrition Module 1
Nutrition Module 2
Nutrition Module 3

Supervised exercise classes 2x/wk–6 mos + encourage 3x/wk independent Weekly weight tracking @ class

1 week following V1

Adamo et al. Contemporary Clinical Trials, 2013
Assessment - Post Partum

**Maternal**
- Weight, Height
- Body Composition (DXA - 12 mos only)
- Diet (7d Record)
- Physical Activity (7d PAR + accel.)

**Offspring**
- Weight, Height
- Body Composition (skin folds)
- Infant Feeding Practices
- Physical Activity/Sleep (accel.)
- Motor milestones
Unpublished MOM trial outcome data

**Gestational Weight Gain**

- INT: 50% exceeded
- CON: 63% exceeded

**Birthweight**

- INT: 3400 grams
- CON: 3600 grams

**Temporal Pattern in Step Counts**

- Baseline (< 20 wks)
- 26-28 wks
- 36-40 wks

**Postpartum Weight Retention**

- PPWR 3 mos
- PPWR 6 mos
Unpublished MOM trial outcome data
Unpublished MOM trial outcome data
Unpublished MOM trial outcome data
Unpublished MOM trial outcome data

### Light Physical Activity

- **Baseline (< 20 wks)**
- **26-28 wks**
- **36-40 wks**

### MVPA

- **Baseline (< 20 wks)**
- **26-28 wks**
- **36-40 wks**

### Sedentary Time

- **Baseline (< 20 wks)**
- **26-28 wks**
- **36-40 wks**

### Sleep

- **Baseline (< 20 wks)**
- **26-28 wks**
- **36-40 wks**
### Unpublished MOM trial outcome data

<table>
<thead>
<tr>
<th></th>
<th>MVPA (V2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GWG (kg)</td>
<td>0.213 (p=0.193)</td>
</tr>
<tr>
<td>WFL z-score (6 mos)</td>
<td>-0.329 (p=0.044)</td>
</tr>
<tr>
<td>PPWR (3 mos)</td>
<td>0.342 (p=0.041)</td>
</tr>
<tr>
<td>PPWR (6 mos)</td>
<td>0.432 (p=0.010)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>GWG (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFL z-score (6 mos)</td>
<td>0.120 (p=0.428)</td>
</tr>
<tr>
<td>PPWR (3 mos)</td>
<td>0.645 (p=0.000)</td>
</tr>
<tr>
<td>PPWR (6 mos)</td>
<td>0.393 (p=0.009)</td>
</tr>
</tbody>
</table>
Systematic Reviews or Meta-analyses performed by researchers around the world exploring the impact of Dietary, Physical activity or Mixed interventions during the prenatal period have shown that \textbf{YES} we can modify GWG!!

\textbf{What works?}

Improving Diet Quality
- appropriate kcal intake

Engaging in Physical Activity

Reducing Sedentary Time

All of these?
Physical activity and gestational weight gain: a review

The effects of physical activity and physical activity plus diet interventions on body weight in overweight or obese women who are pregnant or in postpartum: A systematic review and meta-analysis of randomized controlled trials

JiWon Choi *, Yoshimi Fukuoka, Ji Hyeon Lee

Obesity Prevention

Interventions designed to limit gestational weight gain: a systematic review of theory and meta-analysis of intervention components

B. Hill, H. Skouteris and M. Fuller-Tyszkiewicz

Changing diet and gestational weight

Physical exercise during pregnancy: a systematic review

B. Gardner¹, J. Wardle¹, L. Poston²

Can gestational weight gain be modified by increasing physical activity and diet counseling? A meta-analysis of interventional trials

Juli Streuling, Andreas Beyerlein, and Rüdiger von Kries
Clinical tools - Resources

Offer Education and Resources

- Education to improve understanding is central to self-management.
- Help women identify and seek out CREDIBLE pregnancy specific health behaviour and weight-management information and resources.

Refer to Appropriate Providers

- Evidence supports that weight management throughout pregnancy is more successful using an interdisciplinary team approach.
- Choice of appropriate provider (e.g. GP, OB, MFM, midwife, nurse, dietitian, exercise physiologist, psychologist, etc.) should reflect identified DRIVERS and complications of excessive weight gain as well as BARRIERS to weight management during this critical period.

Arrange Follow-Up

- Follow-up is essential, given the prevalence of excessive weight gain in pregnancy and the subsequent high probability of post-partum weight retention, which can lead to immediate and downstream complications.
- The child-bearing years are a natural period of weight cycling (for those who have experienced more than one pregnancy), and returning to a healthy weight should be encouraged.
IOM posters for clinic use:

- Pregnancy weight gain guidelines poster
- Available at: http://www.iom.edu/healthypregnancy
Dispel Myths…

♥ Eat twice as healthy NOT twice as much

-Human pregnancy is slow and thus has very modest nutritional requirements
  - Most can be obtained from healthy, balanced diet (~10-15% extra kcal in last trimester)
  - No special requirements for additional fat, CHO or protein

-Health Canada recommends: ↑ 340 kcal 2nd trimester and 450 kcal in the 3rd

-What you are eating is as important as how much

www.hc-sc.gc.ca/fn-an/nutrition/prenatal/hwgdp-ppspg-eng.php
Dispel Myths…

♥ Physical activity will NOT harm you and/or your baby

- PARMed X for pregnancy
  

- Canadian Physical Activity Guidelines
  - 150 min/wk in 10 + minute bouts

Benefits of exercise during pregnancy

- Regular exercise has many positive maternal effects:
  - Decreased pains/discomforts and depression, shorter labour and delivery, fewer complications, and faster recovery postpartum (Clapp, 2006)
  - Protective effects with regard to Preeclampsia and GDM (Dempsey et al, 2005)

- Fetal benefits include:
  - Decreased risk for SGA and LGA (Juhl M et al, 2010)
  - ‘training’ effects similar to adaptations in adults (i.e., lower HR and increase HR variability) in offspring of exercising (30mins 3x/wk) mothers (May L et al, 2010)

- Resistance Exercise does NOT adversely affect gestational age, new born birth size and overall health, or type of delivery (Barakat et al, 2009)

- Specific guidelines available for OW/OB pregnant women as a way to prevent onset and/or manage excess weight and comorbidities (e.g., GDM) (Mottola et al, 2009)
Hello! Are you pregnant or thinking about having a baby? If so, please come with me to talk about gaining the right amount of weight during your pregnancy so that both you and your baby will have a healthy start together.

FIGURE 3-7 Screen from the interactive infographic. NOTE: Available at http://www.iom.edu/healthypregnancy.
CONGRATULATIONS!

Pregnancy is an exciting time for you and your family, and it also is a good time to focus on your health. Gaining too little or too much weight during pregnancy may affect your health and the health of your baby. To help, check out this easy-to-use pregnancy weight tracker customized just for you.

Bring this tracker with you to discuss with your health care provider what your weight gain goals for your pregnancy should be.

WHY YOUR WEIGHT IS IMPORTANT

Many women enter pregnancy overweight or obese. While any woman can be overweight, the condition is more common among Hispanic women.

START YOUR PREGNANCY AT A HEALTHY WEIGHT

Reaching a healthy weight before you get pregnant is the first step to ensuring your health and the health of your child. If you know you are overweight and you plan to become pregnant, work with your health care provider to develop a weight-loss plan before becoming pregnant.

GAIN WITHIN THE GUIDELINES

The weight categories are based on your pre-pregnancy body mass index (BMI), which is a measure of body fat based on your height and weight. Talk to your health care provider to determine which weight category you fit into and how much weight you should gain during your pregnancy.

HOW TO USE THIS TRACKER

Every pregnancy is different. What worked for your mom or aunts may not work for you. This tracker will help you work with your health care provider to customize a weight gain plan that is right for you. Follow the steps below to ensure you are on the right track.

1. Write down your weight before pregnancy.
2. Ask your health care provider for three things: your height, weight, and BMI. Write this information down in the boxes provided.
3. Start recording your weight as early as you can. Every week, place a dot at your current weight gain. Connect the dots every week to track and compare your weight with the goals set by you and your health care provider.
4. Discuss your progress when you go in for a check-up and don’t forget to ask for your weight every time!
SmartMoms-Canada: A Mobile Technology for Managing Gestational Weight Gain

Reducing Health Care Costs

Personalized Intervention

Cost-effective

‘Real-time’ technology

Easy and convenient to use

Benefits of Mobile Health Technologies
**SmartMoms-Canada mHealth Intervention**

- **Activity & Sleep**
- **Body Trace Scale**
- **SmartTips**

Data transferred from home environment

Automated Feedback (SmartGraphs, SmartSteps, SmartSleep & SmartTips)

“Health coach” recommendations

Data graphed to illustrate adherence
THANK YOU

My team:

RAs/RCs
Shanna Wilson
Dr. Zach Ferraro
Kimberly Grattan
Alysha Harvey

Grad Students
Kendra Brett
Holly Ockenden
Kevin Belanger

Student volunteers:
Alyse, Ranim, Caitlin, Celeste, Suzanne,
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Barrowman,
Public Health Nutrition for Mothers, Children & Families

The University of Tennessee Knoxville