Pregnancy-induced changes in various body systems that determine the planning and conduct of prenatal exercise programs

Website: www.uwo.ca/fhs/EPL

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PROGRAM SPINAKER

Fundusze Europejskie Wiedza Edukacja Rozwój
Rzeczpospolita Polska
NAWA
Unia Europejska Europejski Fundusz Społeczny

Children's HEALTH RESEARCH INSTITUTE

Objectives:

- To describe main anatomical and physiological pregnancy changes
- To describe pregnancy-induced adaptations to exercise to protect mother and fetus
- To describe the role of PA exposure on preventing obesity, type 2 diabetes & CVD
- Does intensity and duration matter regarding prevention of chronic disease?
- To consider adherence in exercise planning and conduct

Pregnancy = 40 weeks; Term ≥37 weeks

Hormones – progesterone, estrogen, placental hormones (affects every system)

Trimester 1
(conception to 12 weeks)

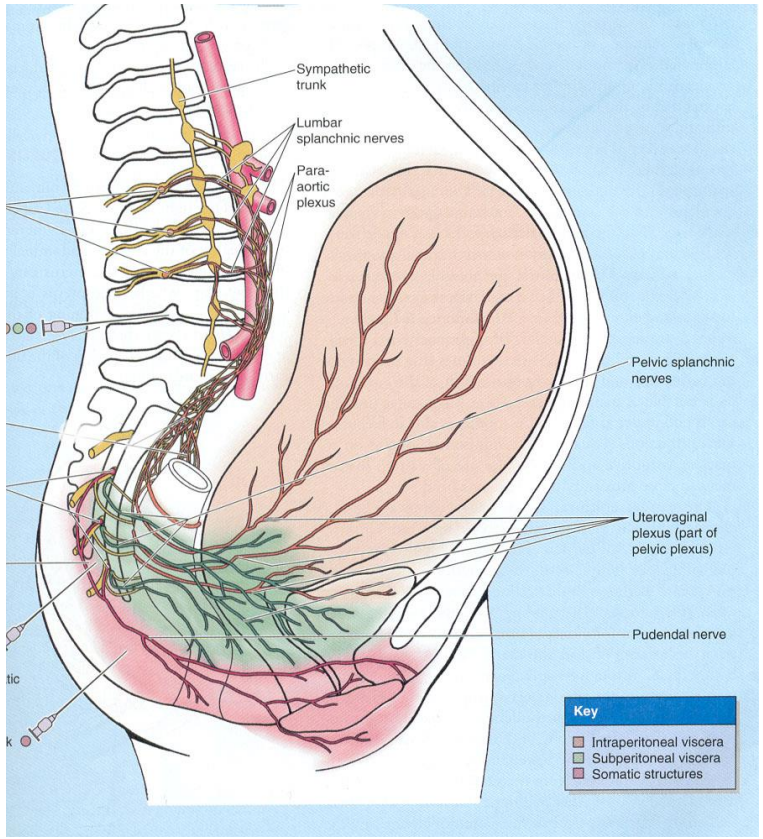
Trimester 2
13 to 27 weeks

Trimester 3
28 to 40 weeks

Pregnancy & Obstetric Concerns

Anatomical adaptations?
All systems of body affected.

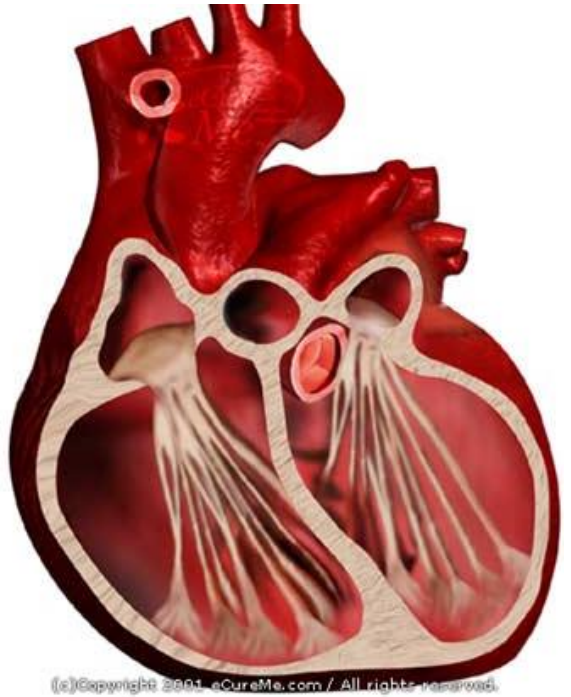
- **heart**
- **thoracic cage**
- **cardiovascular system**
- **digestive system**
- **endocrine system**
- **posture**
- **thermoregulatory system**
- **joints**
- **muscular system**



Pregnancy may offer protection from cardiovascular disease in low risk individuals

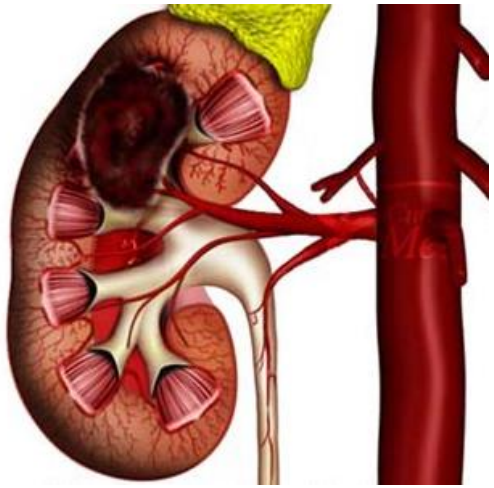
Remodeling of the heart (estrogen-mediated)

- **increase in ventricular cavity**
- **no increase in wall thickness**
- **decrease in afterload – heart doesn't work as hard; drop in aortic pressure**
- **increase in stroke volume and heart rate (15 to 20 beats above NP)**
- **augmented sympathetic drive/ drop in vagal tone increases resting HR**
- **drop in peripheral vascular resistance**



Bo et al. Exercise & pregnancy in recreational and elite athletes: 2019 evidence summary from the IOC expert group meeting. Lausanne. Part 1 – exercise in women planning pregnancy and those who are pregnant. BJSM 50:571-589.

- **CO – increases in 1st trimester (50% up from NP), slight increase in 2nd trimester than plateaus**
- **SV – increases by 10% by the end of 1st trimester; before significant increase in blood volume**
- **Blood volume up to 50% more than NP by 3rd trimester**



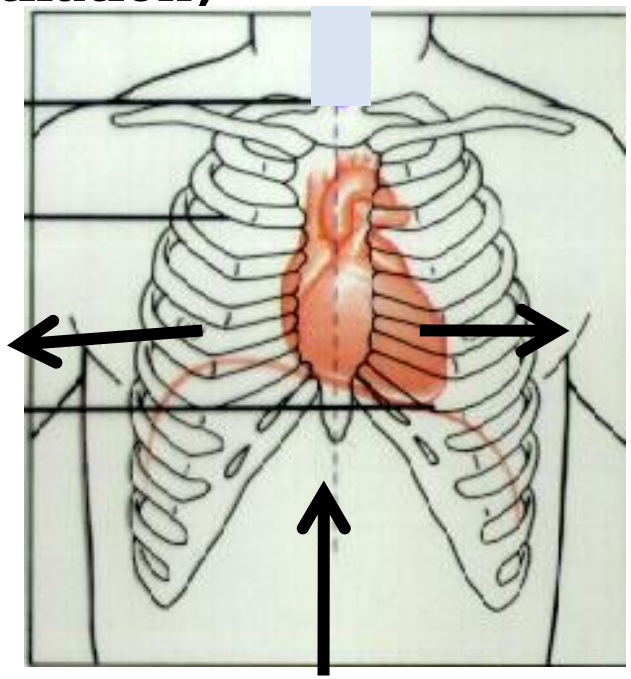
• Pregnancy-induced hormones activates renin-angiotensin-aldosterone system
• Leads to antidiuretic hormone secretion
• Fluid retention to maintain or slightly reduce blood pressure along with decrease in peripheral vascular resistance
• Hypotension – prone to fainting in 2nd trimester <90/60 mmHg

Bo et al. Exercise & pregnancy in recreational and elite athletes: 2019 evidence summary from the IOC expert group meeting. Lausanne. Part 1 – exercise in women planning pregnancy and those who are pregnant. BJSM 50:571-589.

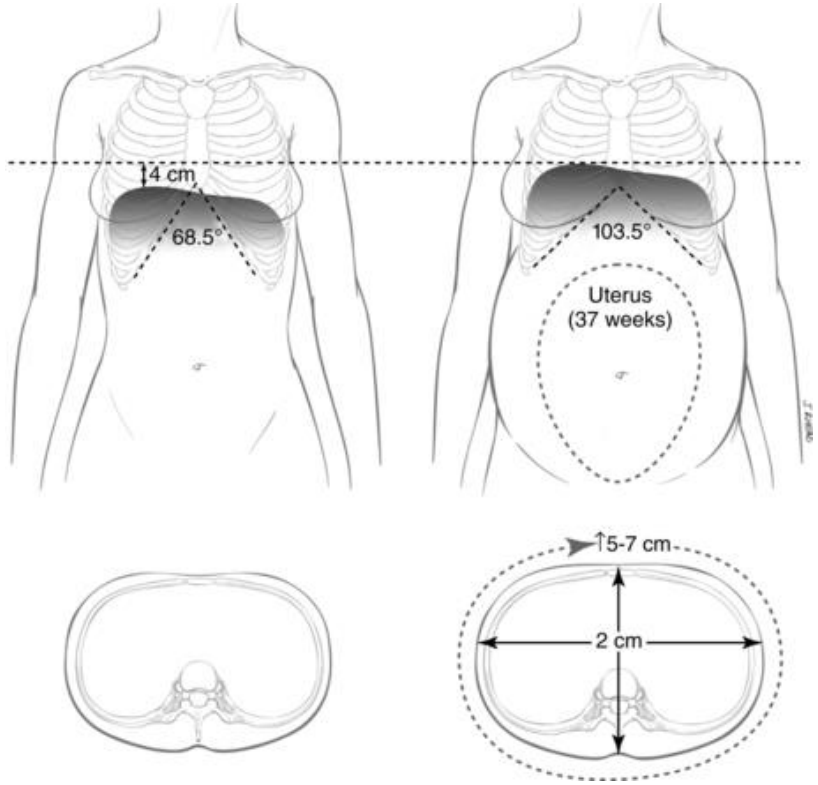
Respiratory adaptations during pregnancy:

- **Higher diaphragmatic mid-position**
- **Reduction-residual lung volume & expiratory reserve; increased inspiratory capacity**
- **Increased sensitivity to carbon dioxide**
- **Breathe more frequently (hyperventilation)**

- **Remodeling & expansion of the thoracic cage**



Hegwald & Crapo Clin Chest Med 2011



Bo et al. Exercise & pregnancy in recreational and elite athletes: 2019 evidence summary from the IOC expert group meeting. Lausanne. Part 1 – exercise in women planning pregnancy and those who are pregnant. BJSM 50:571-589.

Dyspnea (Shortness of breath)

- **Especially in late pregnancy is normal at rest and upon exertion**
- **May be due to increase in respiratory effort as result of mechanical alterations**
- **Seems to go away with exercise**

Bo et al. Exercise & pregnancy in recreational and elite athletes: 2019 evidence summary from the IOC expert group meeting. Lausanne. Part 1 – exercise in women planning pregnancy and those who are pregnant. BJSM 50:571-589.

Relative resting VO_2 (ml/kg/min; oxygen uptake) reflects increase in body mass, thus slight decrease in each trimester

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Metabolic Adaptations:

Normal Pregnancy:

Cascade of hormonal events results in:

- **an increase in maternal blood glucose production (drop in liver glycogen storage)**
- **an increase in insulin production (overworked pancreas)**
- **an increase in insulin resistance at peripheral tissues (skeletal muscle and fat)**
- **a decrease in peripheral utilization of glucose**

More maternal glucose available for fetal usage

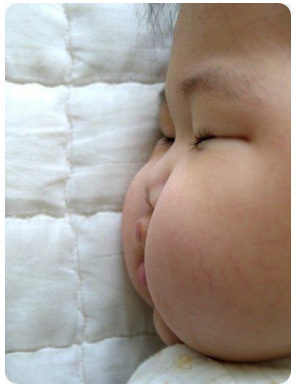
Mottola & Artal 2016. Role of exercise in reducing gestational diabetes mellitus. Clin Obstet Gynecol 59(3):620-628.

During late gestation,
30-50% of maternal blood glucose is used by conceptus

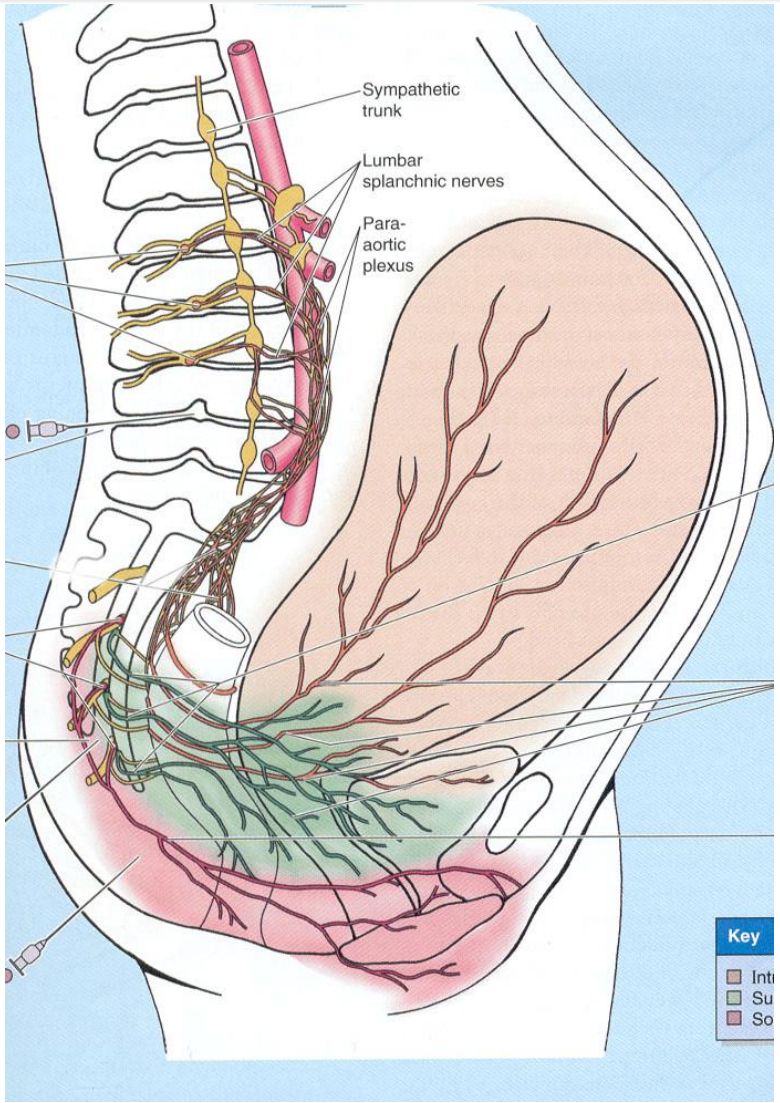
Uterine glucose utilization is dependent upon maternal blood glucose concentration

Pregnant individuals
Hyperinsulinemic
Hyperglycemic

Problem:
Too much glucose in maternal system – *Gestational diabetes* develops (glucose intolerance)
Baby continues to use high maternal glucose resulting in large baby (>4.0 kg)
<u>Mom</u>: At risk for type 2 diabetes after baby is born
<u>Baby</u>: At risk for diabetes and obesity

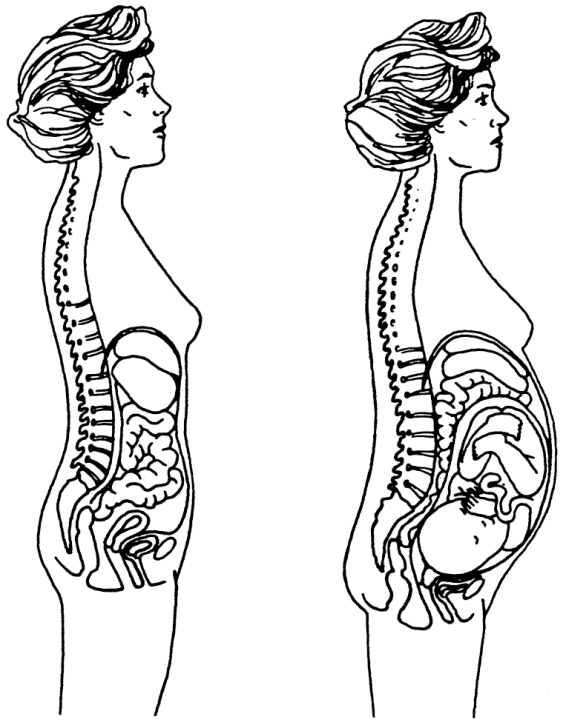


Mottola & Artal 2016. Fetal and maternal metabolic responses to exercise during pregnancy. Early Hum Dev. 94:33–41



Other pregnancy considerations?

- intestines
- constipation
- hemorrhoids
- bladder
- pelvic floor
- lumbosacral pain
- posture



- **Centre of gravity shifts**
- **Postural changes; lower back problems**
- **Pelvic nerves, sciatica**
- **Gait changes**

Back of infant head against pubic bones of mother, facing the opposite direction

Pregnancy and aerobic conditioning are biological processes that involve striking physiological adaptations, and these may occur in the same, or in opposite directions, depending on the specific variable being studied.

Physiological responses to pregnancy (by trimester) and aerobic conditioning in the non-pregnant state as measured at rest.

Variable	First trimester	Second Trimester	Late Pregnancy	Aerobic conditioning
Cardiac output ($L \cdot min^{-1}$)	↑↑	↑	-	- or↑
Heart Rate ($beats \cdot min^{-1}$)	↑↑	- or ↑	-	↓↓
Stroke Volume (mL)	↑↑	- or ↑	-	↑↑
Blood Volume (L)	↑↑	↑	-	↑
Oxygen uptake ($mL \cdot kg^{-1} \cdot min^{-1}$)	-	↓	↓	↑

Mottola 2008. Performance in the pregnant woman:maternal & foetal considerations. In: Physiological Bases of Human Performance During Work & Exercise. Elsevier. Chpt. 12

Cardiorespiratory responses to exercise during pregnancy:

- **Absolute O_2 uptake well preserved in those who maintain physical activity**
- **Resting HR increased due to pregnancy**
- **HR increases at a slower rate in response to increases in exercise intensity (lag time)**
- **Functional cardiac reserve (Max HR – Resting HR) decreased during pregnancy due to elevated resting HR**
- **HR target zones must be derived & validated from pregnant individuals**
- **Efficiency of exercise for weight-supported exercise not changed during pregnancy**
- **For weight-bearing exercise, the energy requirement increases in proportion to maternal body weight gain**

Mottola 2008. Performance in the pregnant woman:maternal & foetal considerations. In: Physiological Bases of Human Performance During Work & Exercise. Elsevier. Chpt. 12

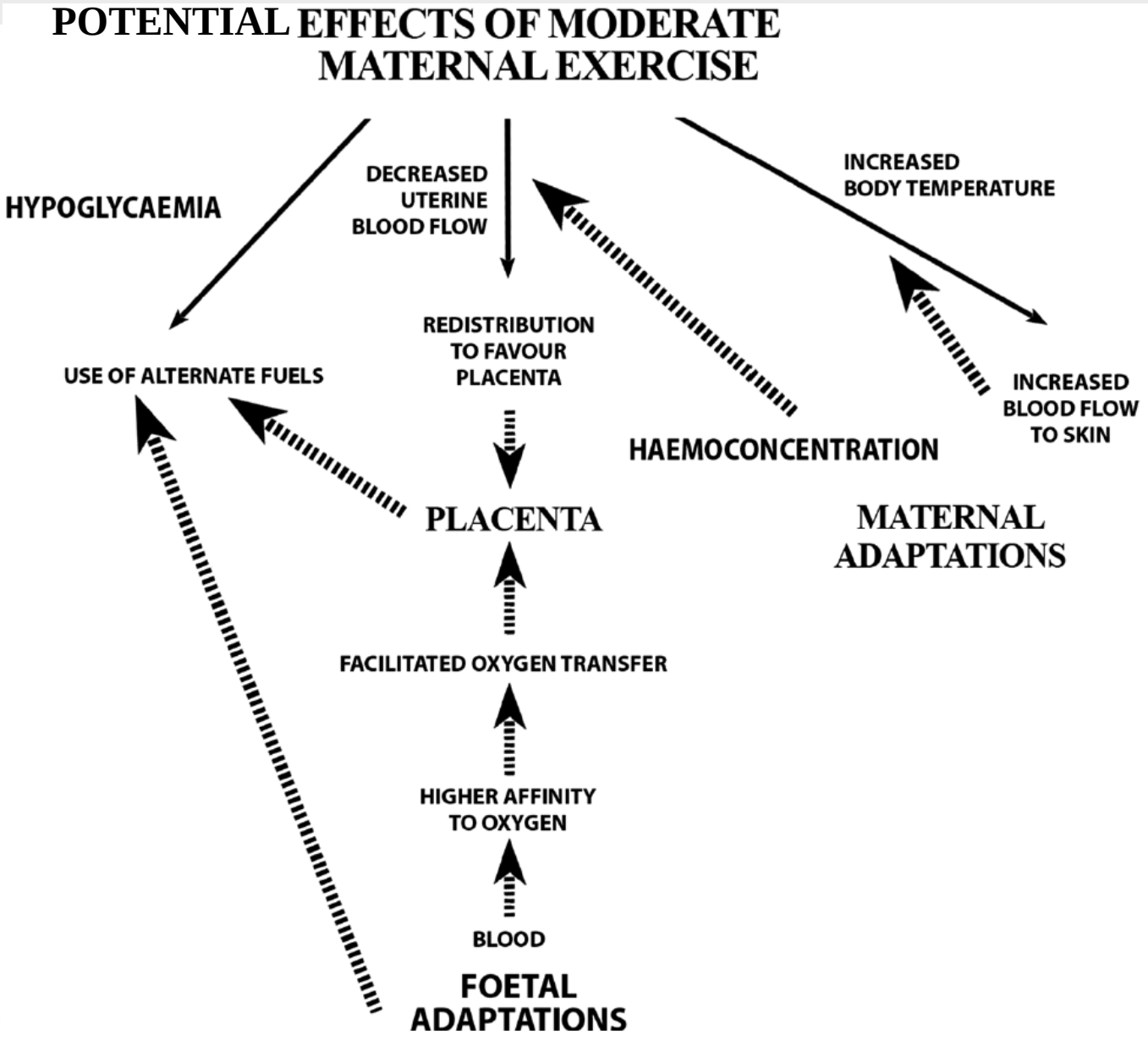


Figure 1 Flow chart of maternal, placental and fetal adaptations that occur in a low-risk pregnancy to protect the fetus from *potential* risks of maternal exercise. The solid arrows represent *potential* effects of maternal exercise. The dashed arrows represent fetal, placental and maternal adaptations that occur in a low-risk pregnancy to counterbalance these potential maternal exercise effects (adapted with permission from Mottola[35]).

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Bo et al. Exercise & pregnancy in recreational and elite athletes: 2019 evidence summary from the IOC expert group meeting. Lausanne. Part 1 – exercise in women planning pregnancy and those who are pregnant. BJSM 50:571-589.

POTENTIAL EFFECTS OF MODERATE MATERNAL EXERCISE

↓'d UTERINE BLOOD FLOW

BLOOD SHUNTED TO WORKING MUSCLES OF THE MOTHER

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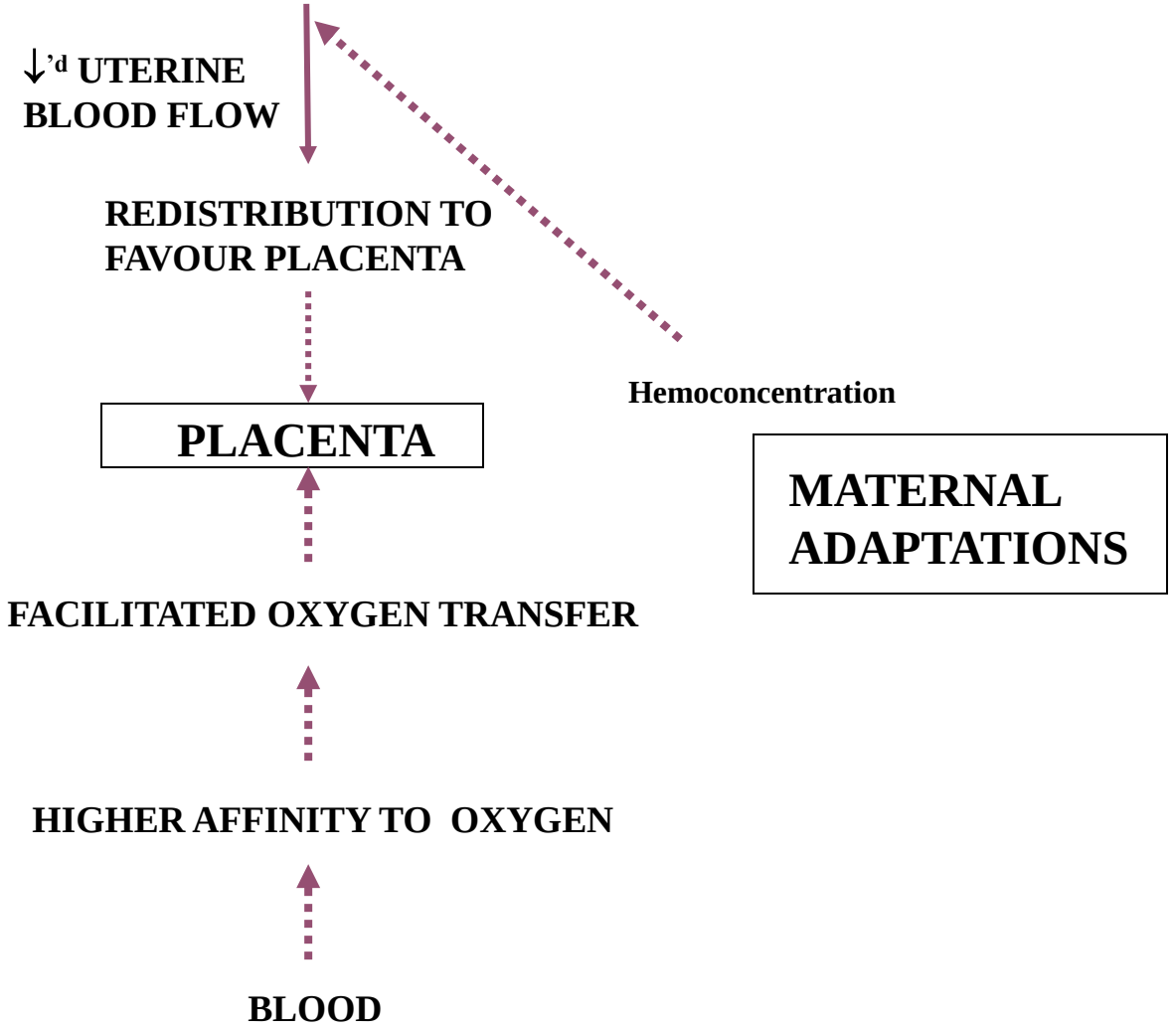
POTENTIAL EFFECTS OF MODERATE MATERNAL EXERCISE



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POTENTIAL EFFECTS OF MODERATE MATERNAL EXERCISE

↑'d BODY TEMPERATURE

- Fetal metabolism and growth generates heat – about 0.6 º C higher
- Heat dissipates from higher to lower
- Fetal temp dependent on maternal temp, fetal metabolism and uterine blood flow

INCREASE FETAL BODY TEMPERATURE

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POTENTIAL EFFECTS OF MODERATE MATERNAL EXERCISE

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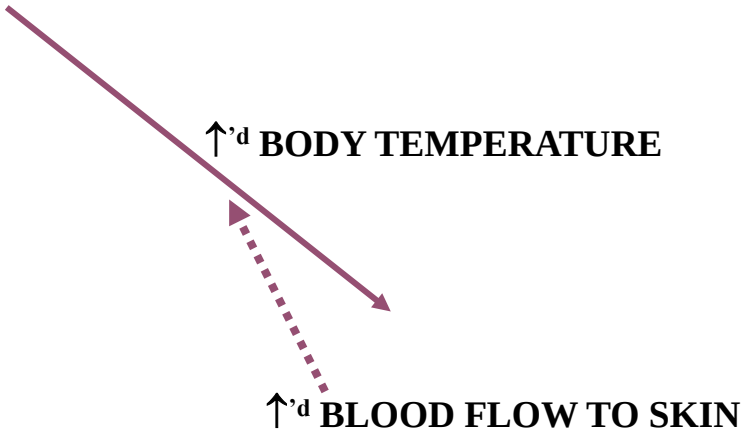


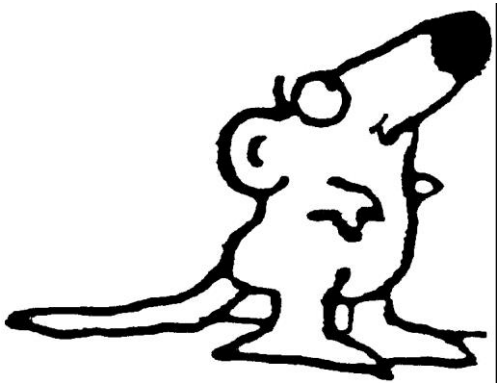
- **Downward shift in threshold for body temp**
- **Evaporative heat loss at lower temp**
- **Decreased vascular tone, increase plasma vol**
- **Sweating occurs at lower temperature**
- **Thermoregulation improves**

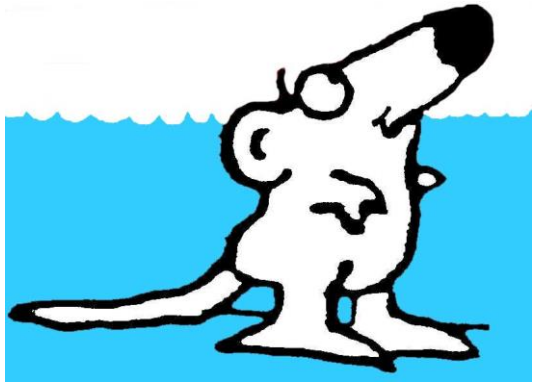
MATERNAL ADAPTATIONS

Bo et al. Exercise & pregnancy in recreational and elite athletes: 2019 evidence summary from the IOC expert group meeting. Lausanne. Part 1 – exercise in women planning pregnancy and those who are pregnant. BJSM 50:571-589.

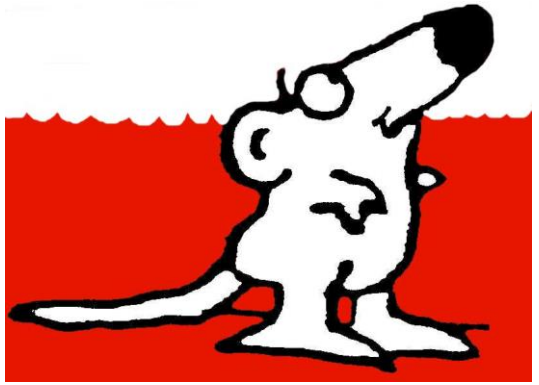
Mottola et al. 1993. Int. J. Sports Med. 14:248-51.

CONTROL

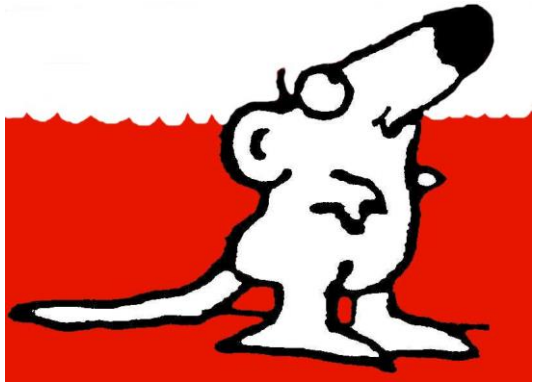




CWS
34.6°C



WWC
37.6°C



WWS
37.6°C

EFFECTS OF EXERCISE/IMMERSION ON CORE TEMPERATURE CHANGES

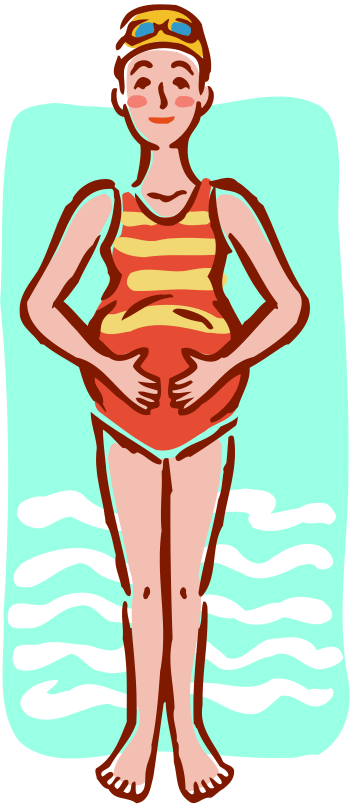
Group	Observations	Daily Core Change °C Mean (SEM)	Water Temperature °C Mean (SEM)
CWS	18	-0.56 (0.12)	34.6 (0.39)
WWS	18	+2.30 (0.09)*†	37.6 (0.12)
WWC	17	+1.51 (0.09)*	37.6 (0.17)

* p<0.01 vs CWS
† p<0.01 vs WWC

Mottola et al. 1993. Int. J. Sports Med. 14:248-51.

Mottola et al. 1993. Int. J. Sports Med. 14:248-51.

RESULTS



Chronic exercise (swimming) in cool water may regulate maternal body temperature with no fetal developmental alterations

Chronic exercise (swimming) in warm water should be avoided because of potential teratogenic effects

Osorio et al. 2003. Comp. Biochem. Physiol. 135:605-11.

Effects of prenatal exercise on incidence of congenital anomalies and hyperthermia: a systematic review and meta-analysis

Brit J Sports Med 2019; 53:116-123.

Margie H Davenport,[1] Courtney Yoo,[1] Michelle F Mottola,[2] Veronica J Poitras,[3] Alejandra Jaramillo Garcia,[3] Casey E Gray,[4] Nick Barrowman,[5] Gregory A Davies,[6] Amariah Kathol,[1] Rachel J Skow,[1] Victoria L Meah,[7] Laurel Riske,[1] Frances Sobierajski,[1] Marina James,[1] Taniya S Nagpal,[2] Andree-Anne Marchand,[8] Linda G Slater,[9] Kristi B Adamo,[10] Ruben Barakat,[11] Stephanie-May Ruchat[12]

- **Data suggest moderate/vigorous exercise does not induce hyperthermia or increase odds of congenital anomalies**
- **Most exercise responses were investigated after 12 weeks of gestation when risk of anomalies is low**

Current Recommendations Suggest:
Avoid vigorous PA in excessive heat, especially high humidity (e.g. hot yoga)

Mottola, Davenport, Ruchat et al.
Br J Sports Med 2018;**52**:1339–1346.

POTENTIAL EFFECTS OF MODERATE MATERNAL EXERCISE

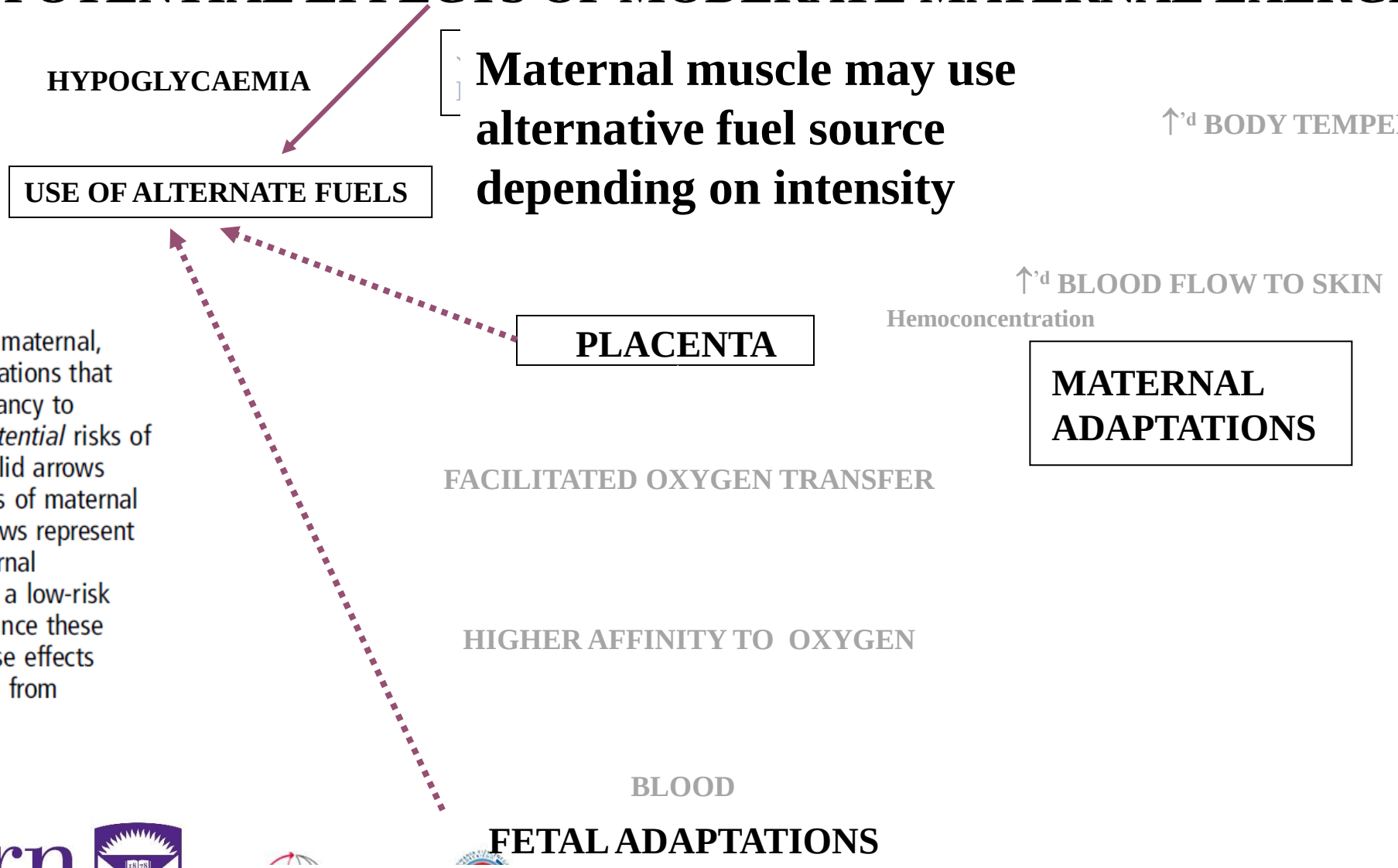
HYPOGLYCAEMIA

FETUS USES
MATERNAL BLOOD GLUCOSE
AS MAJOR ENERGY SOURCE FOR GROWTH
& DEVELOPMENT

Maternal blood glucose is also used by working skeletal muscles

Bo et al. Exercise & pregnancy in recreational and elite athletes: 2019 evidence summary from the IOC expert group meeting. Lausanne. Part 1 – exercise in women planning pregnancy and those who are pregnant. BJSM 50:571-589.

POTENTIAL EFFECTS OF MODERATE MATERNAL EXERCISE



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Low risk for GDM → **Mild-30%** **Mod-70%**

High risk for GDM → **Mild-30%** **Mod-70%**

Nutrition control – all groups

Exercise – 25 minutes; add 2 min/week until 40 mins

Time line:

16-20 weeks – 25 minutes

24-28 weeks – 35 minutes

34-36 weeks – 40 minutes

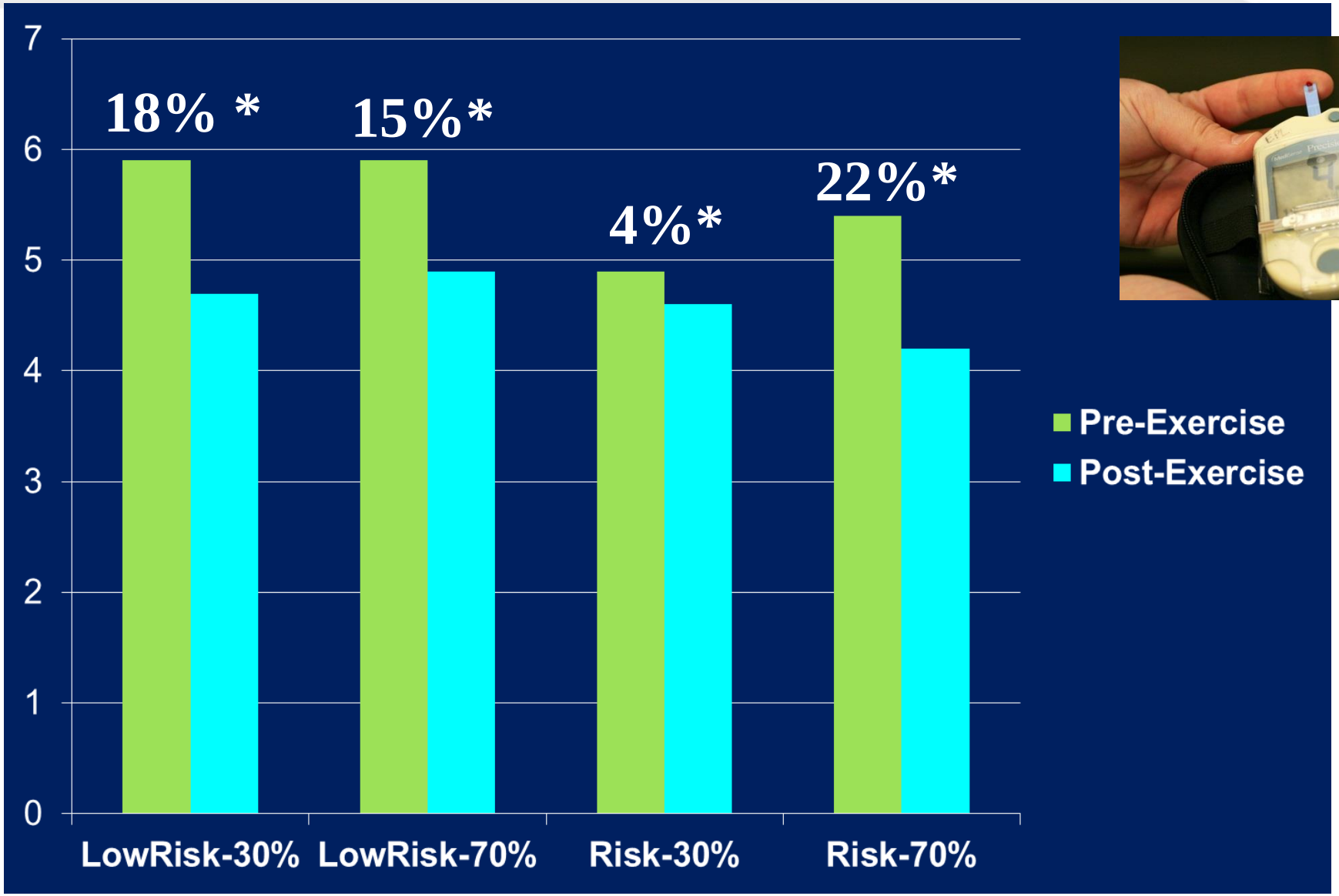
Pre vs post Exercise

Ruchat et al. 2012 – Effect of exercise intensity and duration on capillary glucose responses in pregnant women at low and high risk for gestational diabetes. Diabetes Metab Res Rev 28: 669–678.

Ruchat et al. 2012 – Effect of exercise intensity and duration on capillary glucose responses in pregnant women at low and high risk for gestational diabetes. Diabetes Metab Res Rev 28: 669–678.

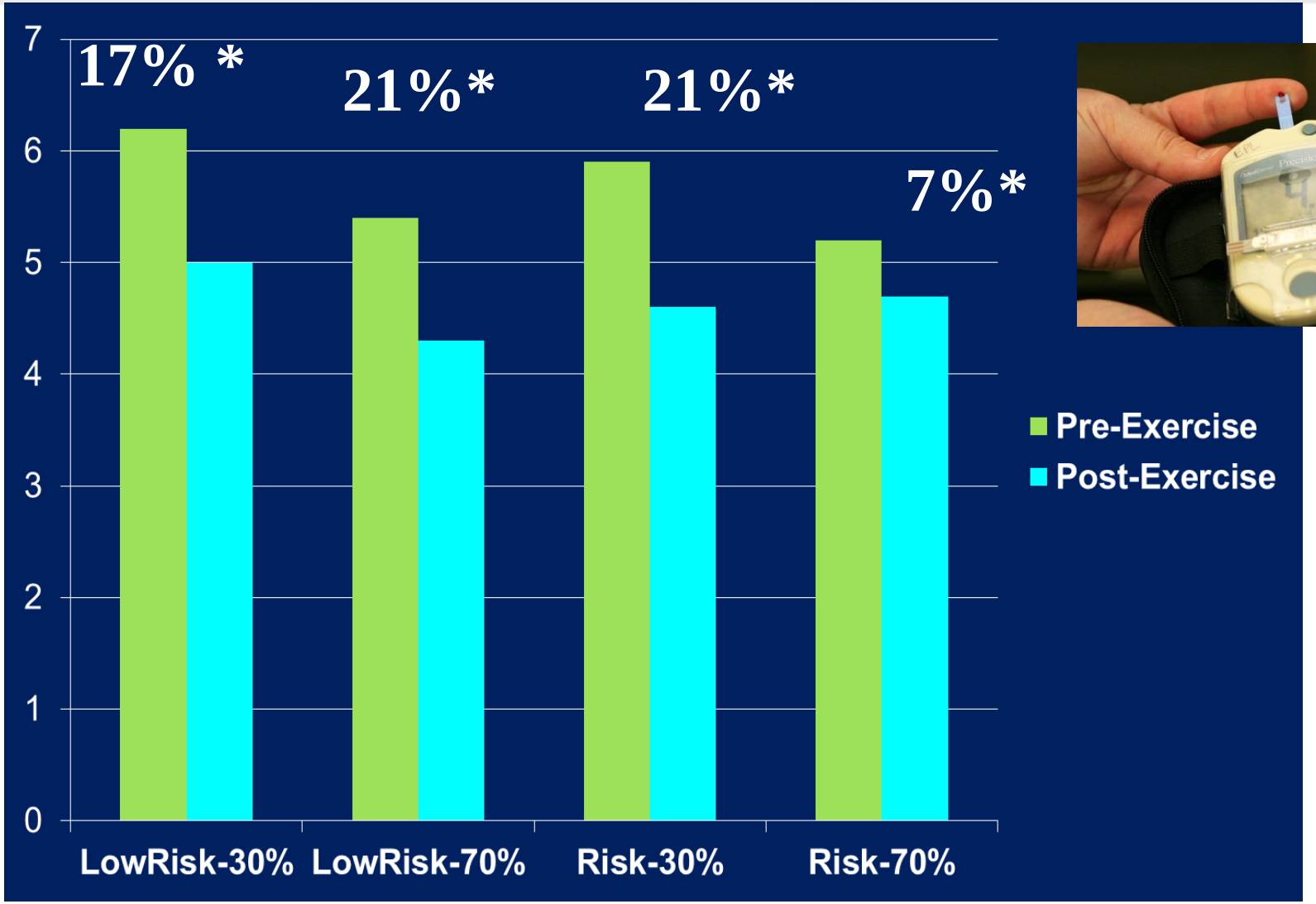
	Low-risk women for GDM		At risk women for GDM	
	LR-30%	LR-70%	R-30%	R-70%
	N=12	N=12	N=11	N=11
Age (years)	30.8 ± 2.6	30.5 ± 4.7	31.3 ± 3.9	32.3 ± 3.6
Pre-pregnancy body mass (kg)	61.1 ± 6.9	60.4 ± 4.5	72.6 ± 14.6*	65.2 ± 10.0*
Pre-pregnancy BMI (kg/m^2)	22.3 ± 1.8	20.9 ± 1.7	25.4 ± 5.8*	24.4 ± 4.7*
Body mass at study entry (kg)	64.8 ± 6.6	65.1 ± 6.9	78.3 ± 14.7*	71.1 ± 11.4*
BMI at study entry (kg/m^2)	23.7 ± 1.7	22.5 ± 2.3	27.4 ± 5.8*	26.6 ±5.3*
Weight gain before the intervention (kg)	3.7 ± 1.6	4.7 ± 3.1	5.7 ± 3.1	5.9 ± 2.2
Peak oxygen consumption (VO_2 peak, mL/kg/min)	26.4 ± 3.3	28.7 ± 5.6	24.8 ± 5.1	25.5 ± 4.5
<u>Risk factors for GDM</u>				
Family history of diabetes (n)	0	0	6	7
History of GDM, PCOS (n)	0	0	3	0
Previous baby of ≥4.0 kg (n)	0	0	1	1
Pre-pregnancy BMI ≥ 25 kg/m^2 (n)	0	0	3	3

Glucose response to Walking for 25 minutes-16-20 weeks



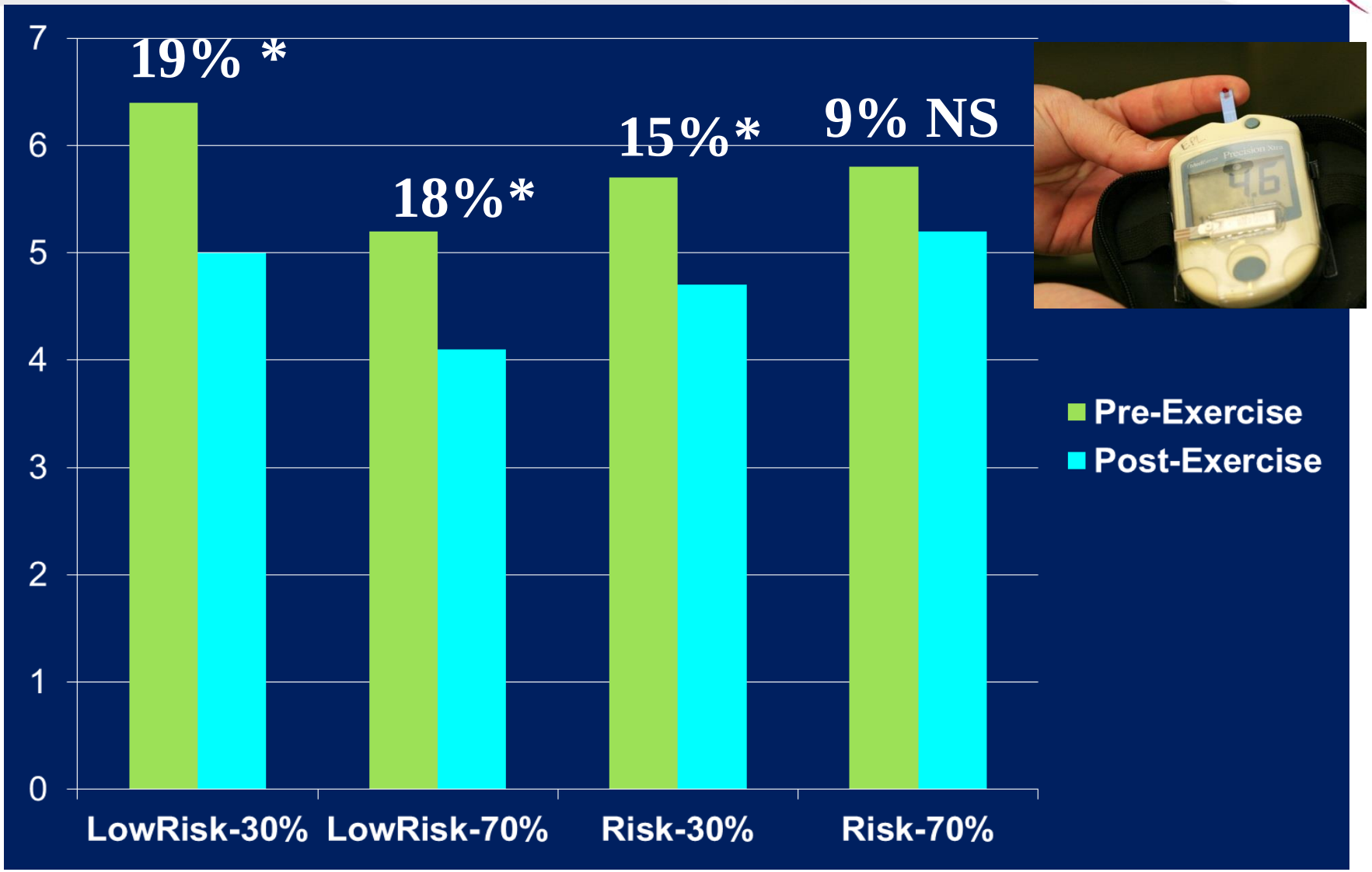
Ruchat S et al. 2012 – Effect of exercise intensity and duration on capillary glucose responses in pregnant women at low and high risk for gestational diabetes. Diabetes Metab Res Rev 28: 669–678.

Glucose response to Walking for 35 minutes- 24-28 weeks



Ruchat S et al. 2012 – Effect of exercise intensity and duration on capillary glucose responses in pregnant women at low and high risk for gestational diabetes. Diabetes Metab Res Rev 28: 669–678.

Glucose response to Walking for 40 minutes-34-36 weeks



Ruchat S et al. 2012 – Effect of exercise intensity and duration on capillary glucose responses in pregnant women at low and high risk for gestational diabetes. Diabetes Metab Res Rev 28: 669–678.

To achieve the best decline in capillary glucose concentrations,

- **Women at low risk for GDM should**
  - **walk for at least 25 minutes at either low or vigorous (moderate) intensity.**
- **Women at risk for GDM should**
  - **walk for 25 min/session at vigorous (moderate) intensity, or**
  - **walk for 35-40 min/session at low intensity.**

Ruchat S et al. 2012 – Effect of exercise intensity and duration on capillary glucose responses in pregnant women at low and high risk for gestational diabetes. Diabetes Metab Res Rev 28: 669–678.

Walking Program of Low or Vigorous Intensity During Pregnancy Confers an Aerobic Benefit

Int J Sports Med 2012; 33: 661–666

Authors S.-M. Ruchat[1], M. H. Davenport[1], I. Giroux[2], M. Hillier[1], A. Batada[1], M. M. Sopper[1], J.-A. Hammond[3], M. Mottola[1,4,5]

30% HRR - Low

70% HRR – "Vigorous"

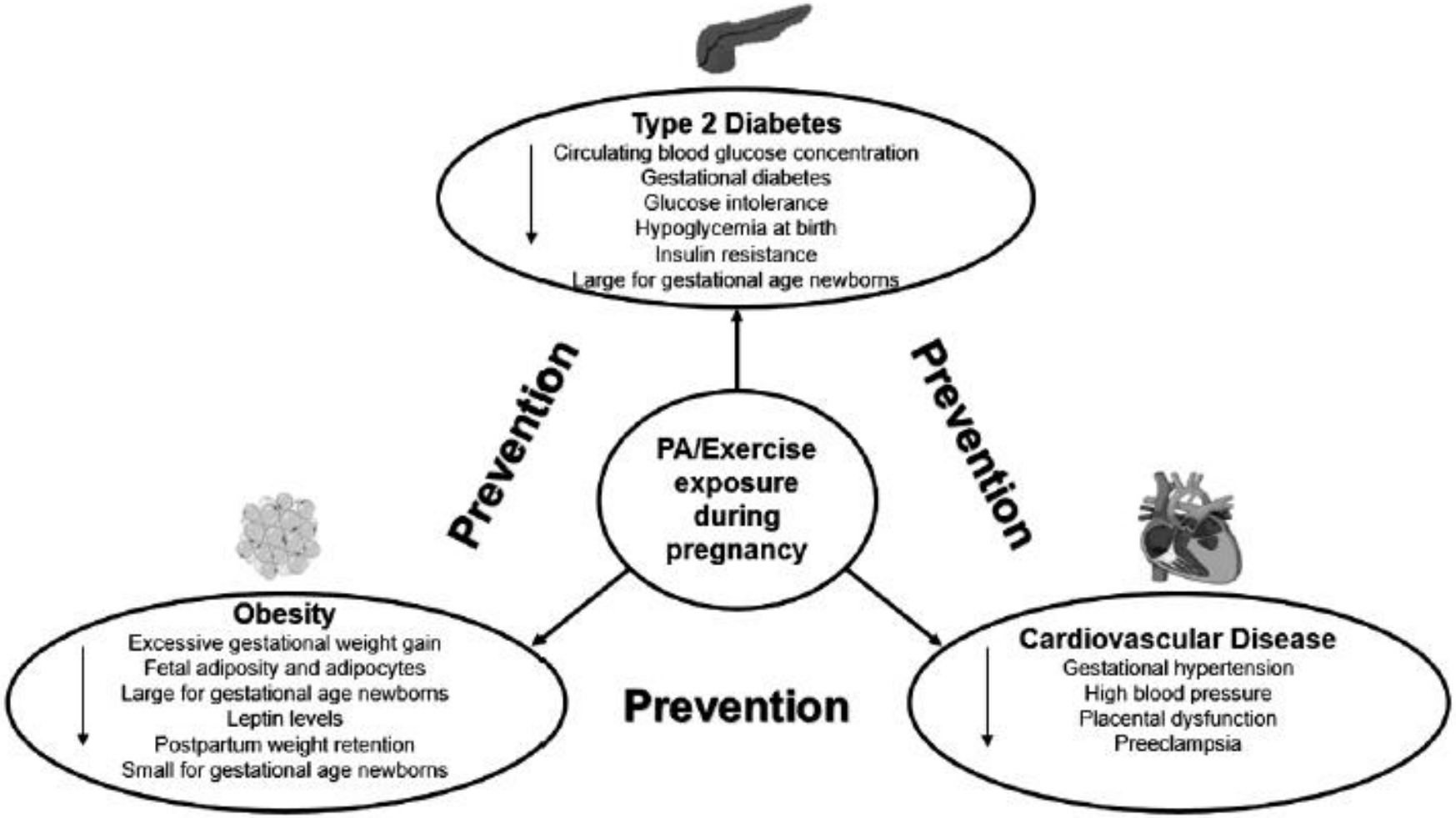
"moderate"

Intensity?

Walking is aerobic activity!!

Role of PA exposure on preventing obesity, type 2 diabetes & CVD

Nagpal & Mottola 2020
Physical activity throughout pregnancy is key to preventing chronic disease. Reproduction 160: R111–R118.



www.neppe.awfis.net

Sequential Introduction of Exercise First Followed by Nutrition Improves Program Adherence During Pregnancy: a Randomized Controlled Trial

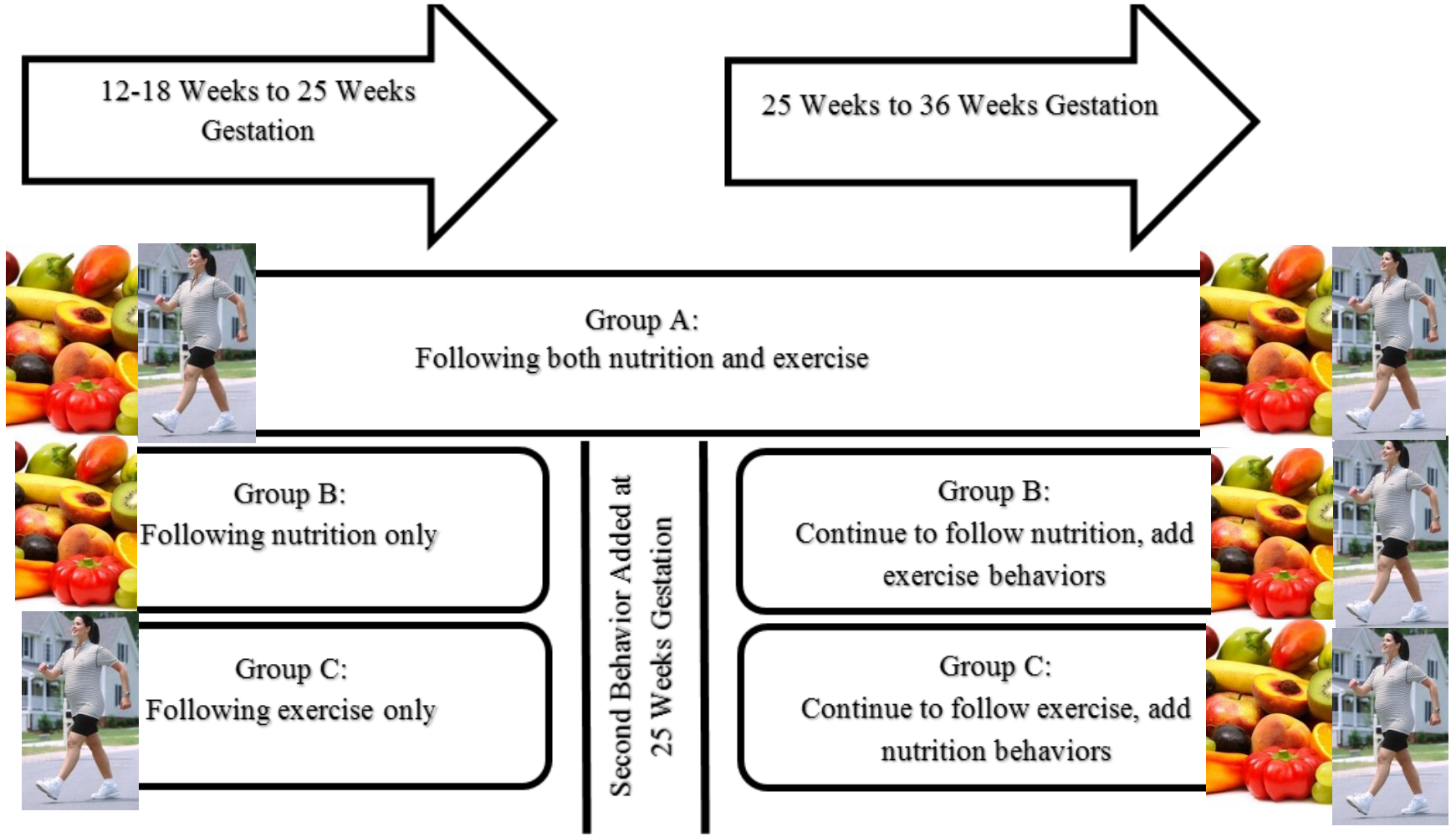
Taniya S. Nagpal[1,2,3] · Harry Prapavessis[2,3] · Christina G. Campbell[4] · Barbra de Vrijer[5,6] · Roberta Bgeginski[1,2,5] · Karishma Hosein[1,2] · Stephanie Paplinskie[1,2] · Mollie Manley[1,2] · Michelle F. Mottola[1,2,5,7]

Gestational diabetic meal plan (Medical nutrition therapy)

<u>Target Total Daily</u>
2000 kcal (8300 kJ);
200 gm carbohydrates
Smaller meals more often

Walking Program
Start at 25 min – increase by 2 min/wk until 40 min, then maintain

Nutrition & Exercise Lifestyle Intervention Program (NELIP)



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Results and Bottom-line: Nagpal et al. 2020 Int J Behav Med

Group C:  **Followed by**  **Increased adherence to the program**

- **Nutrition may be more challenging than a walking program**
- **Exercise first may be a gateway to nutrition behaviour change**
- **Mastering 1 behaviour change (exercise) improves motivation, improving overall adherence to multiple behaviour change program**
- **All groups declined in adherence from 25 weeks to 36 weeks but Group C remained higher even when nutrition was added**

Null Findings or Favors Control

Intervention design may not be optimal for health benefits

True null effect of exercise on health outcomes assessed

High Adherence to the Exercise Intervention

Favors Exercise

Intervention expectations or design are optimal for health benefits

Other confounding variables are contributing to the findings, and/or adherence is not related to the outcome assessed

Exercise and control performed similarly or they may not be comparable (e.g., inactive group is not truly inactive)

A true effect of the intervention was not assessed, barriers to adherence may need to be addressed

Low Adherence to the Exercise Intervention

Lower adherence to the intervention is acceptable for health benefits

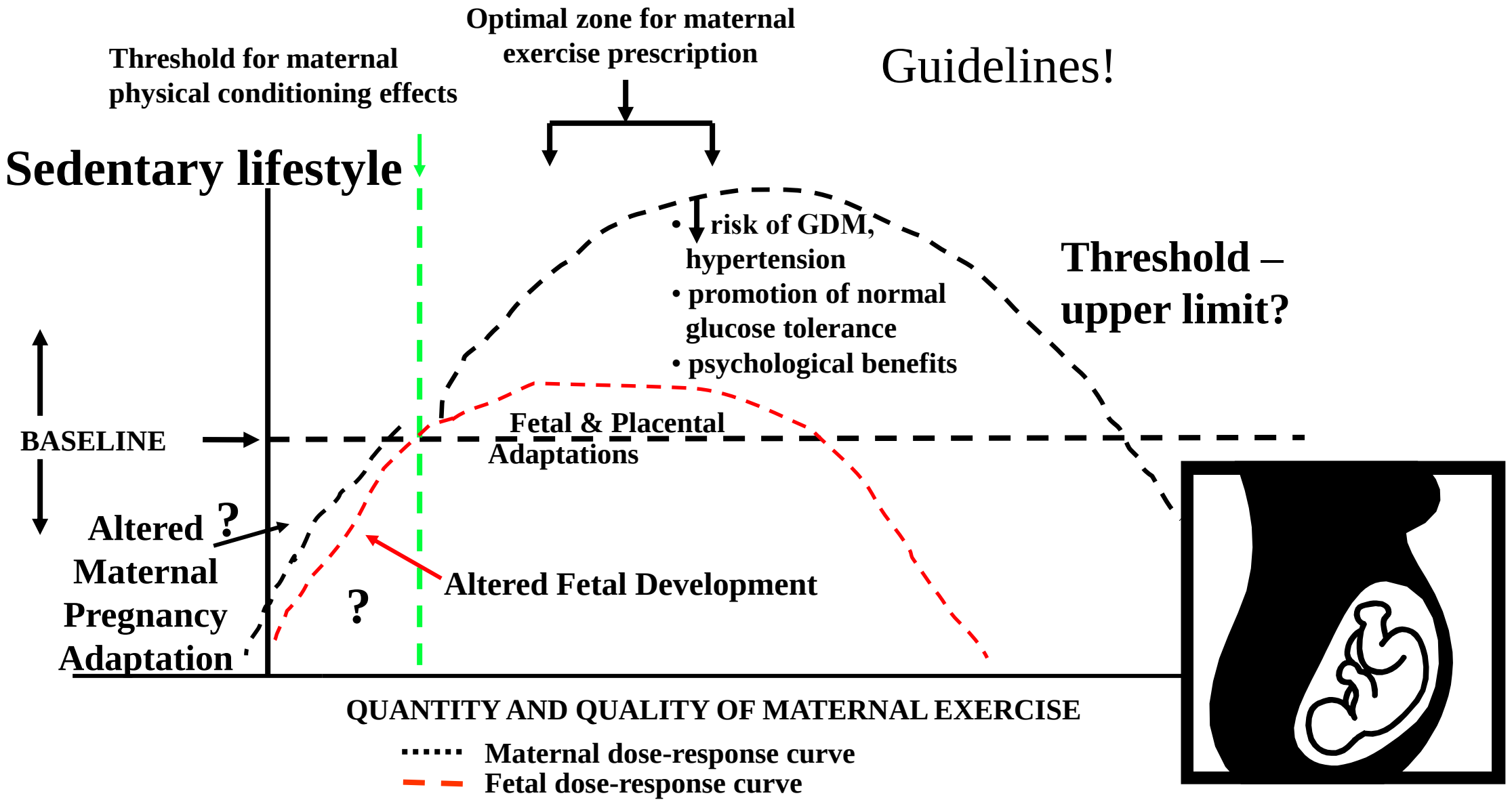
Other confounding variables are contributing to the findings and/or adherence is not related to the outcome assessed

Adherence is key factor to any intervention protocol

If adherence is low, are there other contributing factors?

Nagpal TS, Mottola MF, Barakat R, Prapavessis H. 2021. Adherence is a key factor for interpreting the results of exercise interventions. Physiotherapy 113:8-11.

MATERNAL AND FETAL WELL-BEING



Adapted from Mottola 2008. Performance in the pregnant woman:Maternal & foetal considerations. Chpt.12. In: Physiological Bases of Human Performance during Work & Exercise. Elsevier, USA.

Summary:

- Pregnancy affects every system of the body
- Pregnancy affects posture and gait
- Pregnant women are a special population group that should be medically screened for contraindications to exercise
- How much exercise is too much?
- How much exercise is too little?
    - Chronic disease risk?

- **Prescribing an exercise program not a simple process**
- **Consider each stage of pregnancy – constantly changing**
- **What program is best for specific goals?**
- **Be prepared to modify program based on needs of pregnant individual**
- **Consider chronic disease risk**

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Questions?

"Little Feet – Big Responsibility"