A Dynamic Model Predicting Gestational Weight Gain

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Overview

- Purpose
- Clinical Utility
- Methods
- Validation

How much weight should I gain?

Eating and nutrition | Pregnancy | March of Dimes http://www.marchofdimes.com/nutrition.html

Eating and nutrition

- ✓ It's important to eat a healthy diet during pregnancy.
- ✓ You also need plenty of vitamins and minerals in your diet.
- ✓ Most pregnant women need around 300 extra calories per day.

Hytten FE, Leitch I (1971). The *physiology* of human *pregnancy*.
Hytten FE, Chamberlain G. (1980) *Clinical physiology in obstetrics*

Institute of Medicine (IOM) recommends weight gain by pre-pregnancy BMI

Purpose

TABLE 7-3 New Recommendations for Total and Rate of Weight Gain during Pregnancy, by Prepregnancy BMI

Prepregnancy BMI	Total Weight Gain		Rates of Weight Gain* 2nd and 3rd Trimester	
	Range in kg	Range in lbs	Mean (range) in kg/week	Mean (range) in lbs/week
Underweight (< 18.5 kg/m^2)	12.5–18	28–40	0.51 (0.44–0.58)	1 (1–1.3)
Normal weight (18.5–24.9 kg/m^2)	11.5–16	25–35	0.42 (0.35–0.50)	1 (0.8–1)
Overweight (25.0–29.9 kg/m^2)	7–11.5	15–25	0.28 (0.23–0.33)	0.6 (0.5–0.7)
Obese (≥ 30.0 kg/m^2)	5–9	11–20	0.22 (0.17–0.27)	0.5 (0.4–0.6)

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IOM and NRC, Weight Gain During Pregnancy ed. K.M. Rasmussen and A.L. Yaktine. 2009 Washington D. C.: The National Academies Press.

Why manage gestational weight gain (GWG)?

Purpose

- **Short term:**

  (High BMI) Increased Risk for GDM, Preeclampsia (High GWG) C-section.

- **Long term:**

  (High BMI and GWG) Postpartum weight retention, Increased maternal body fatness and risk factors for cardiovascular disease

- **Large for gestational age infants**

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How does a mathematical model help?

Purpose

1. **Enables setting precise goals with a health care provider.**

2. **Provides Continuous Feedback**

3. **Generates Opportunities to Intervene and Manage Weight Gain**

Schultz, W., Behavioral theories and the neurophysiology of reward. Ann Rev Psychol, 2006. 57: p. 87-115.

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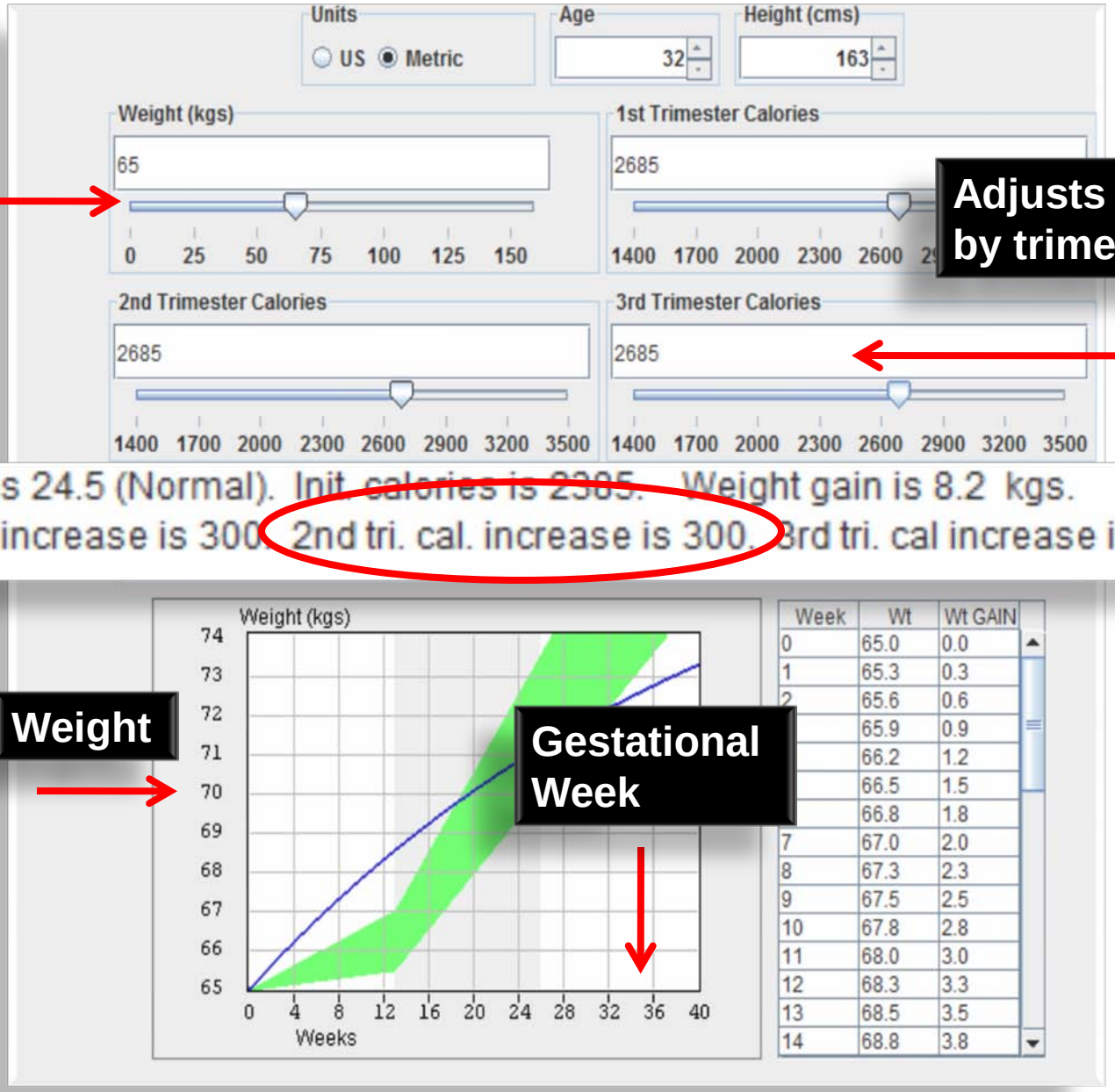
Java Based System to Manage GWG

Clinical Utility

User enters baseline data:
Age
Height
Pre-gravid Weight



Adjusts EI by trimester

Weight

Gestational Week

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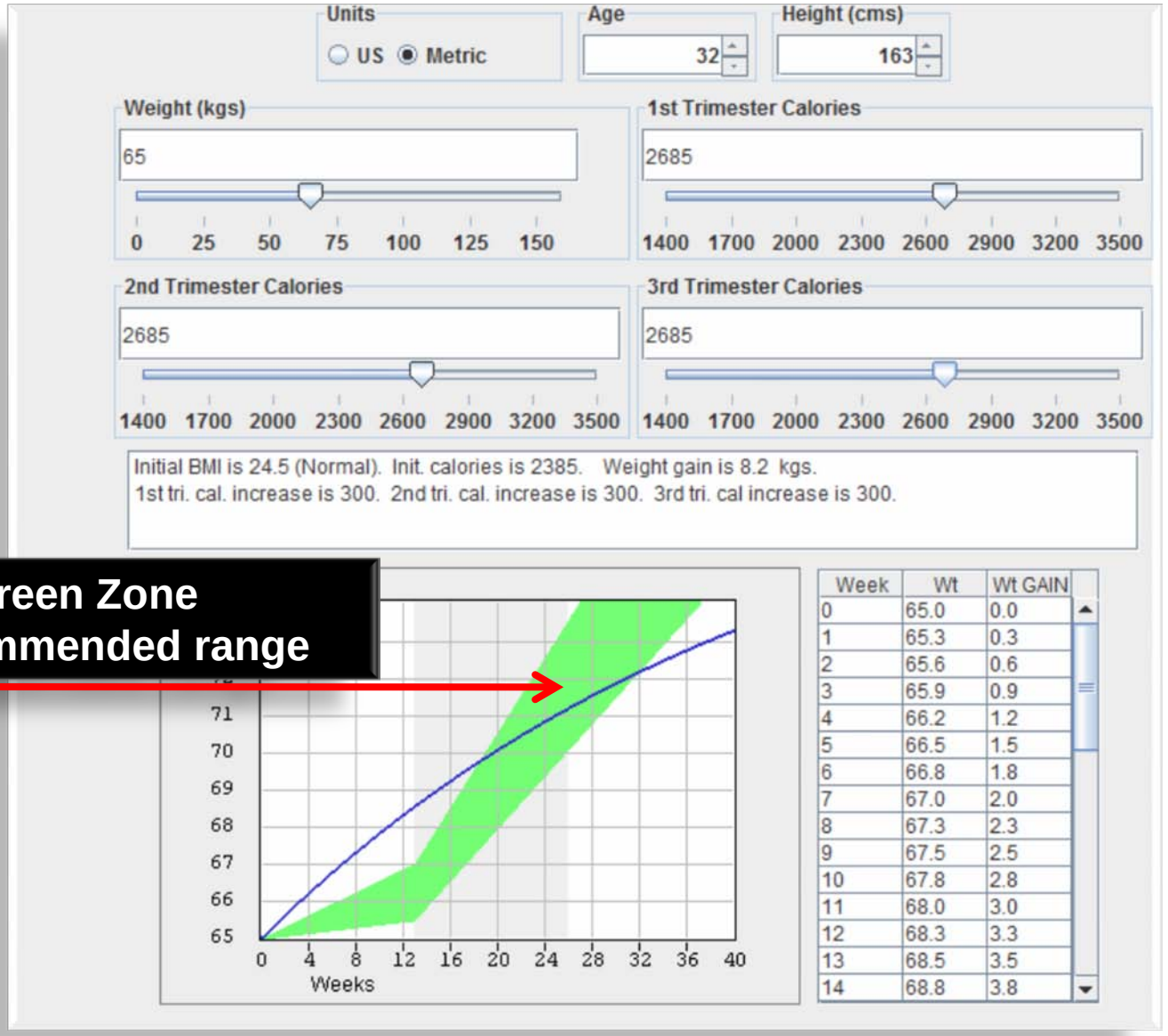
Java Based System to Manage GWG

Clinical Utility



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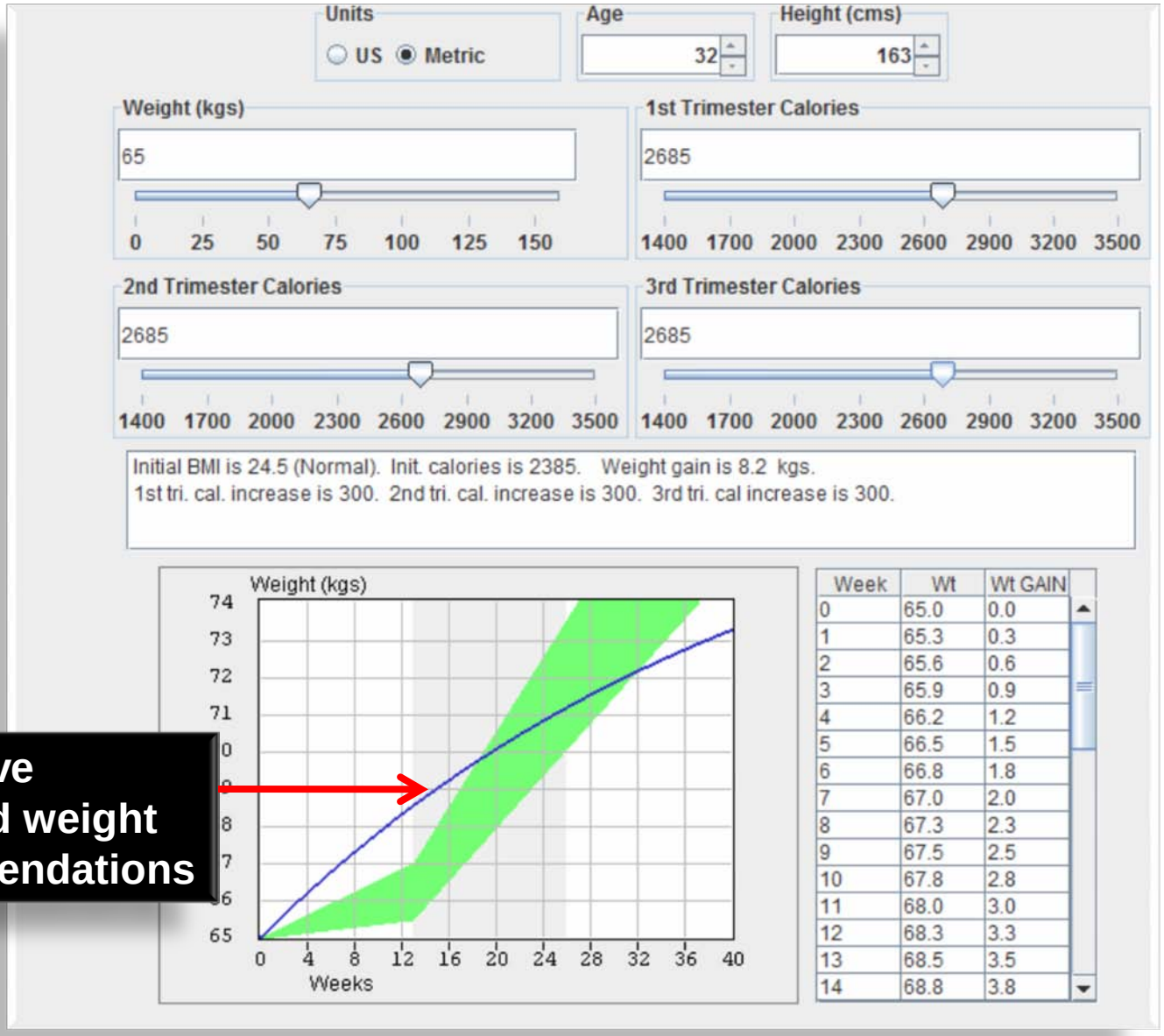
Java Based System to Manage GWG

Clinical Utility



Blue Curve
Model predicted weight
Outside Recommendations

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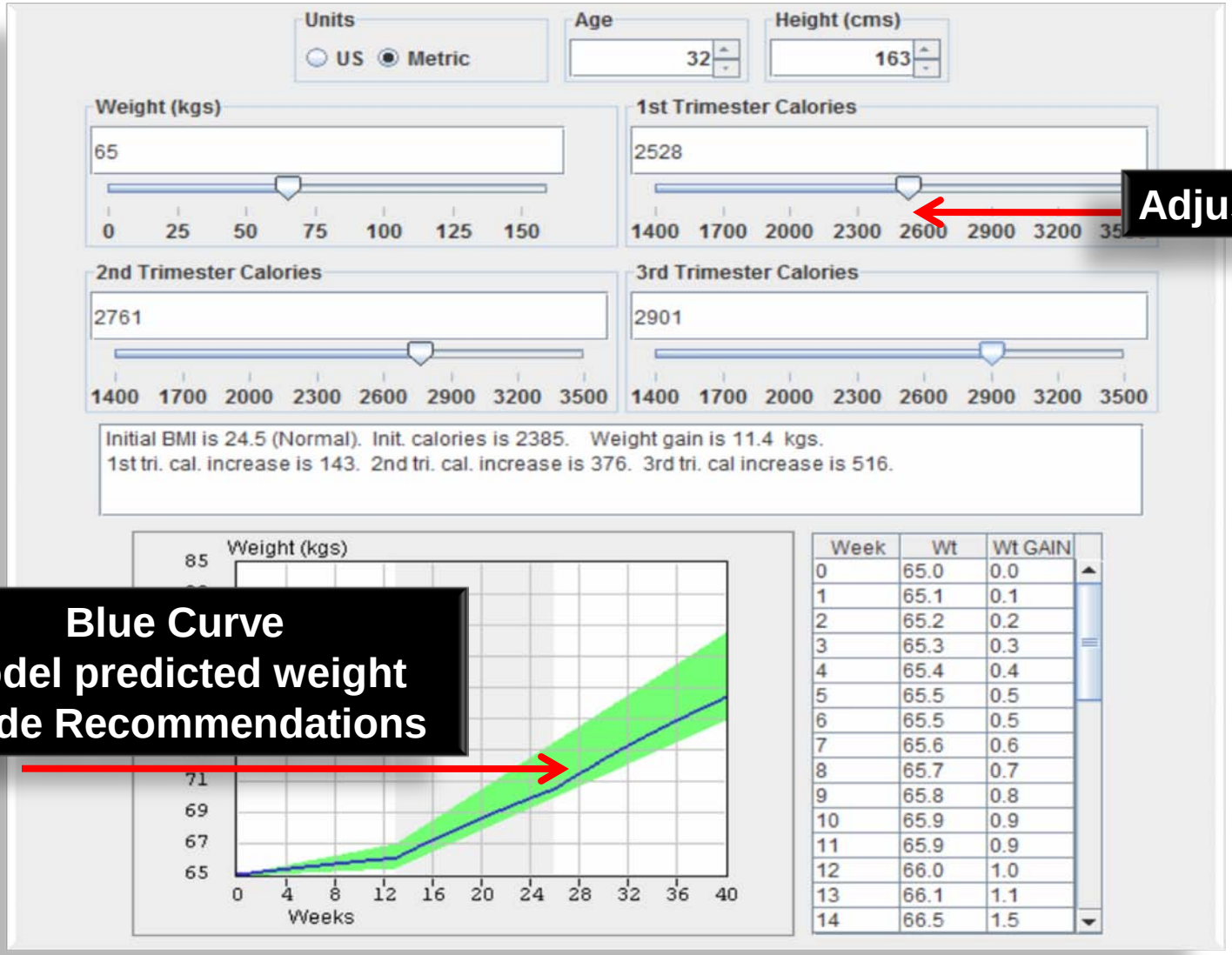
Java Based System to Manage GWG

Clinical Utility



Adjust EI

Blue Curve
Model predicted weight
Inside Recommendations

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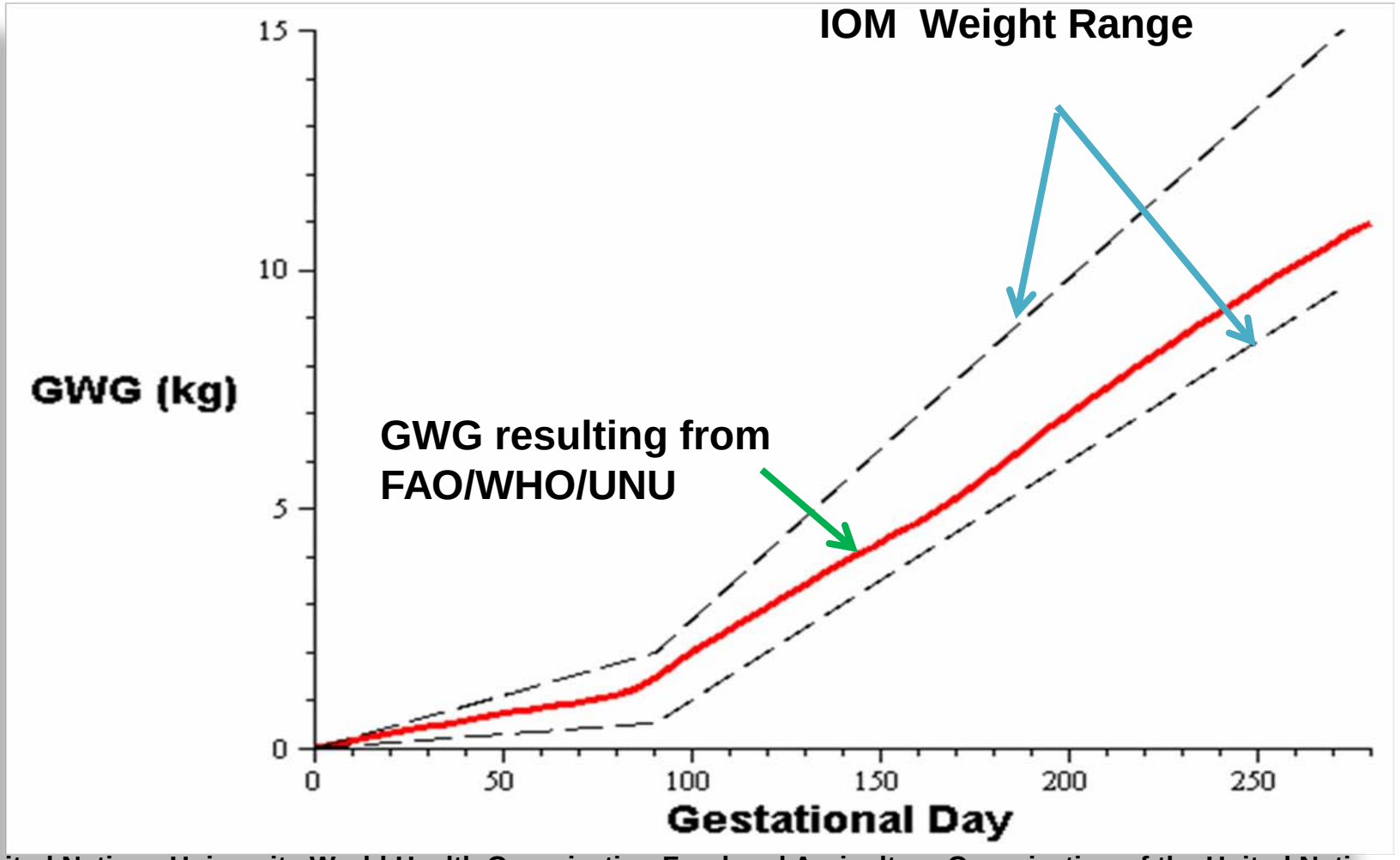
Model can be applied to determine additional EI by trimester

Clinical Utility

Classification	Pre-gravid weight (kg)	Pre-gravid BMI (kg/m^2)	Target GWG (kg) Trimester		Model predicted ΔEI (kcal/d) Trimester		
			1	2 -3	1	2	3
Underweight	45	16.9	0.5-2.0	11.4-15.8	94-184	400-511	442-574
Normal	55	20.7	0.5-2.0	9.1-13.0	94-200	381-492	444-635
Overweight	72	27.1	0.5-2.0	6.0-8.6	117-200	263-333	269-364
Obese	97	36.5	0.5-2.0	4.4-7.0	116-200	223-295	227-326

Model can be used to compare different recommendations

Clinical Utility



United Nations University World Health Organization Food and Agriculture Organization of the United Nations, Human energy requirements. Report of a Joint FAO/WHO/UNU Expert Consultation, Rome, 17-24 October 2001.

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There are pregnancy specific challenges for model development…

Methods

- Pre-Gravid Weight
- Body Composition Measurements
- Components of Energy Expenditure (RMR, TEF,SPA,PA)

The Butte study contains the necessary measurements for model development…

Methods

Simultaneous measurements at weeks 0, 9, 22, 36

- Body composition (body weight, TBW, body volume, bone mineral content)
- Energy expenditures (DLW)
- RMR (respiration calorimetry)

Butte NF et al. Energy requirements during pregnancy based on total energy expenditure and energy deposition. *Am J Clin Nutr.* 2004.

The first mathematical model that predicts weight gain during pregnancy

Methods

$$\underbrace{771\frac{dFFM}{dt}+9500\frac{dFM}{dt}}_{ES}=\underbrace{(1-g)(EI_0+\Delta EI)}_{EI}-\underbrace{(15FFM+1903)}_{EE}$$

$$FFM = 1.8\,FFM(0) - 1.8TBW(0) - 1.8TBP(0) + 0.8FM + 23.5$$

$$TBW = 0.5W + 3.9$$

$$TBP = \begin{cases} -0.05W + 9.3 & \text{if W} \leq 52\text{kg} \\ 0.1W + 1.3 & \text{if } 52 < \text{W} \leq 57.7\text{ kg} \\ 0.08W + 3.1 & \text{if W} > 57.7\text{ kg} \end{cases}$$

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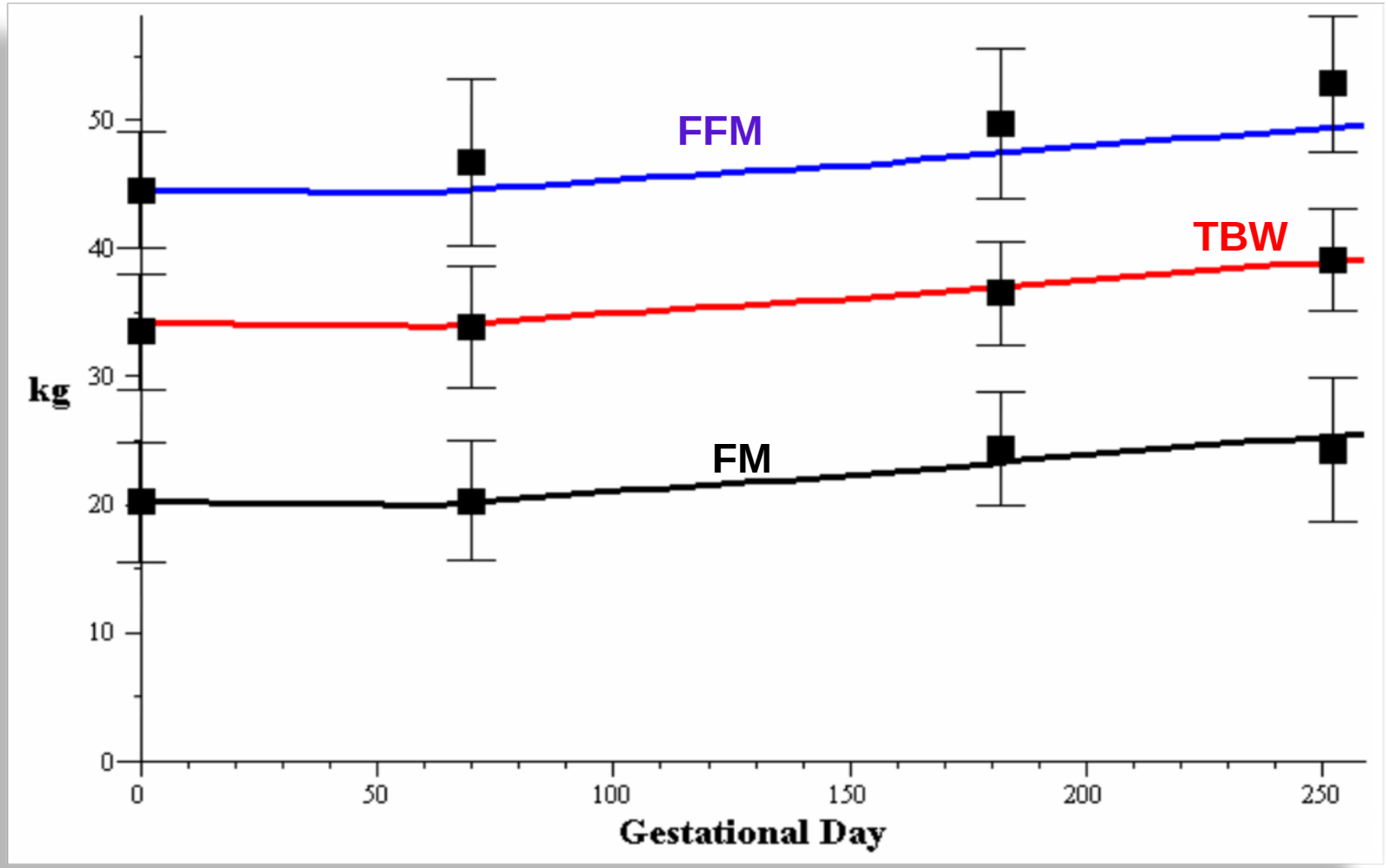
The model agrees with observed data from the Kopp-Hoolihan Study

Validation



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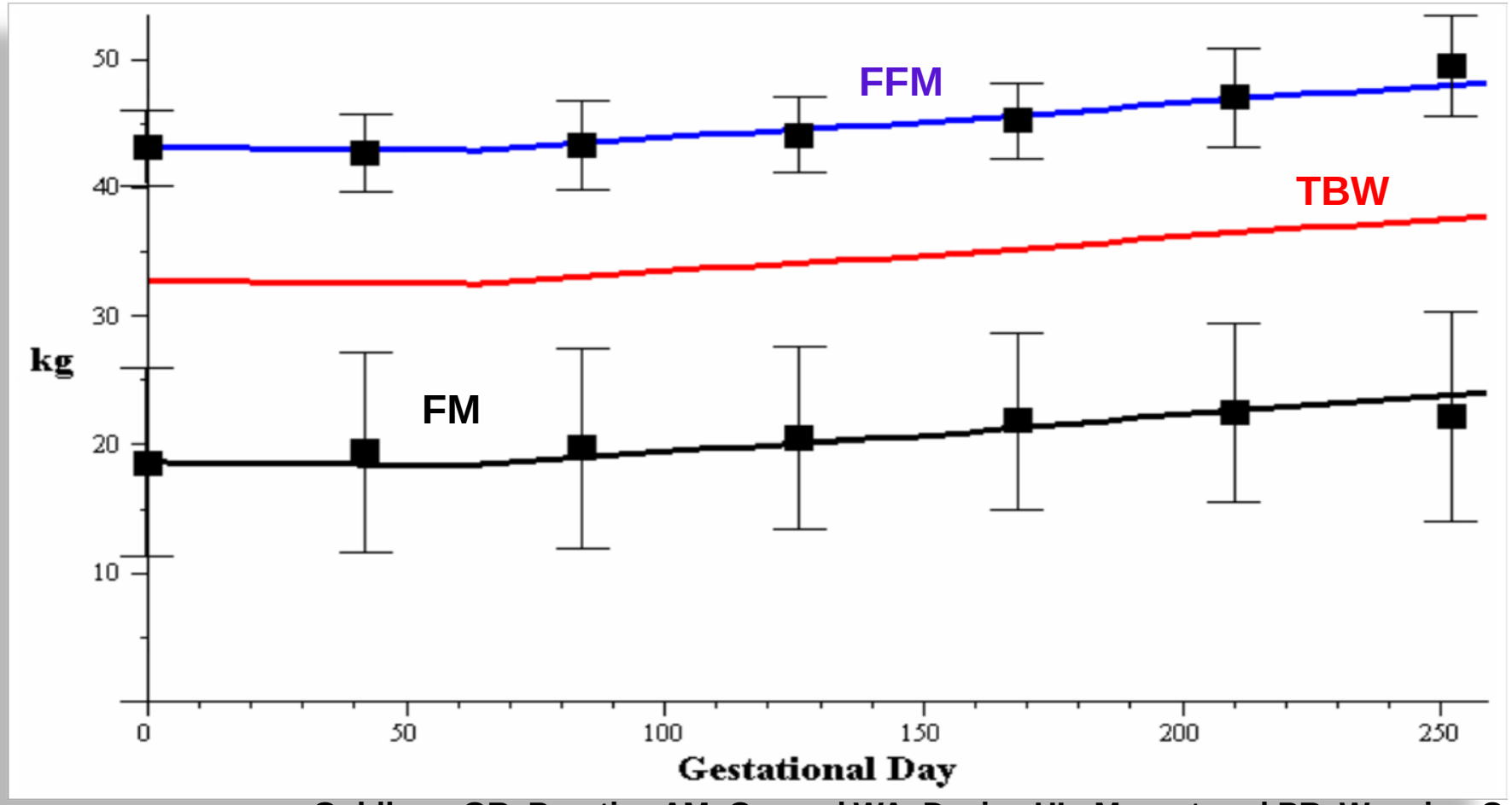
Kopp-Hoolihan LE, et. Al., Longitudinal assessment of energy balance in well-nourished, pregnant women. Am J Clin Nutr. 1999 Apr;69(4):697-704.

Model predictions agree with observed data from the Goldberg study

Validation



Goldberg GR, Prentice AM, Coward WA, Davies HL, Murgatroyd PR, Wensing C, Black AE, Harding M, Sawyer M. Longitudinal assessment of energy expenditure in pregnancy by the doubly labeled water method., *Am J Clin Nutr*. 1993 Apr;57(4):494-505.

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Questions?