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# Post Discharge Nutrition

Jatinder Bhatia, MD, FAAP



**Georgia Health  
Sciences University**

# Declaration of potential conflicts of interest

Regarding this presentation the following relationships could be perceived as potential conflicts of interest:

 No conflicts of interest

# Declaración de potenciales conflictos de intereses

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# Objectives

- Fetal Programming
- “Malnutrition” during hospitalization
- Strategies and current outcomes
- Effects of disease states
- Iron, DHA
- Human milk
- Summary

# Introduction

- Increasing survival of premature and extremely premature infants
- Hospital discharge at younger ages and weight
- Ongoing issues: nutrition, chronic lung disease, retinopathy, gastroesophageal reflux, apnea and immunizations

# Introduction

- Adaptations in the immediate neonatal period may have long-term adverse outcomes
- Cardiovascular disease, hypertension, insulin resistance, diabetes mellitus, obesity
- Preterm infants experience both perinatal malnutrition and poor postnatal growth and malnutrition
- Increasingly unlikely that growth deficits can be made up by hospital discharge

# Introduction

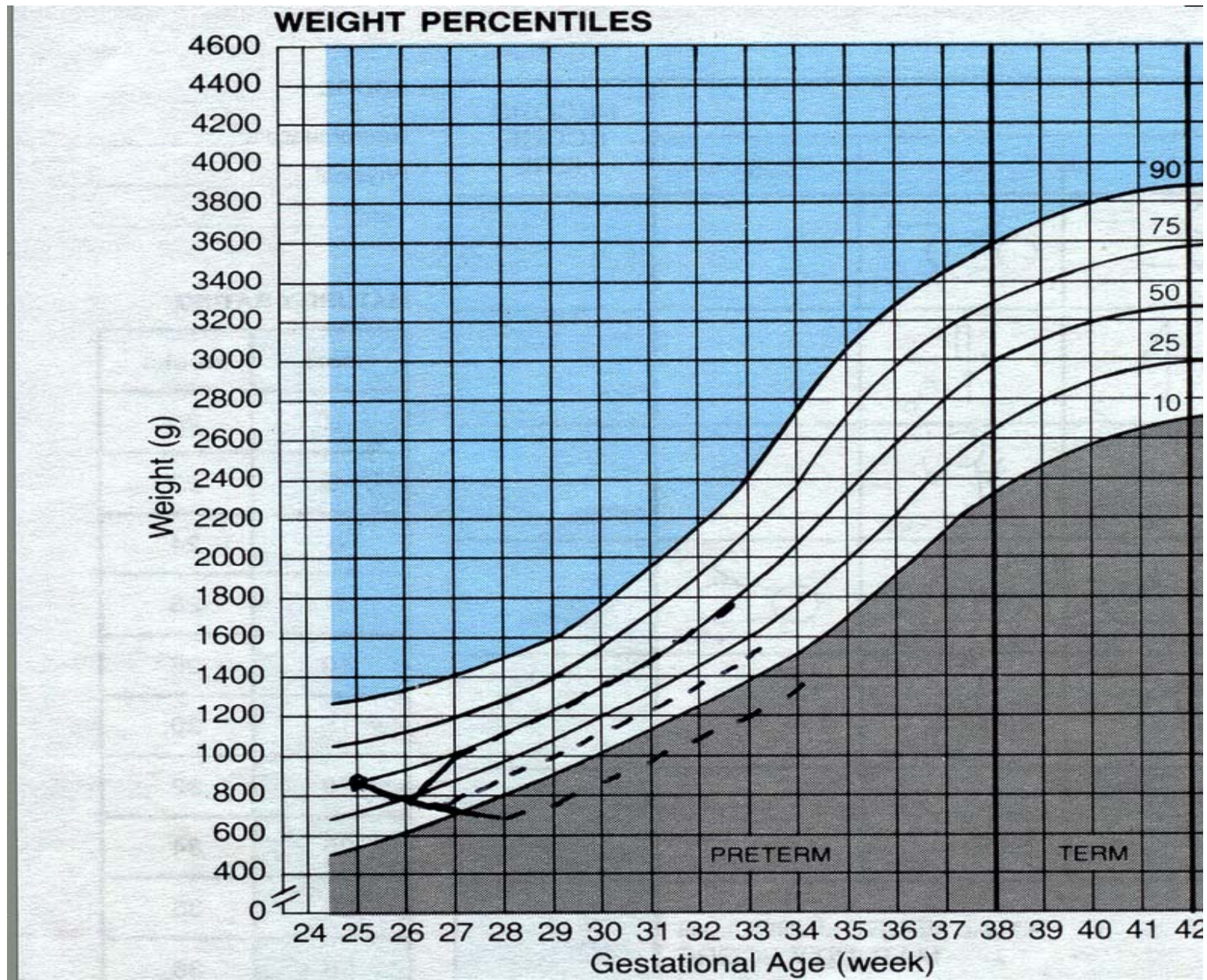
- Abundant evidence in the literature regarding critical windows where a stimulus or insult may have a lifelong consequence on structure or function
- Nutritional insults at a vulnerable period of brain development: permanent effects on brain size, cell number, behavior, learning memory [Dobbing, 1981]

# Fetal Programming

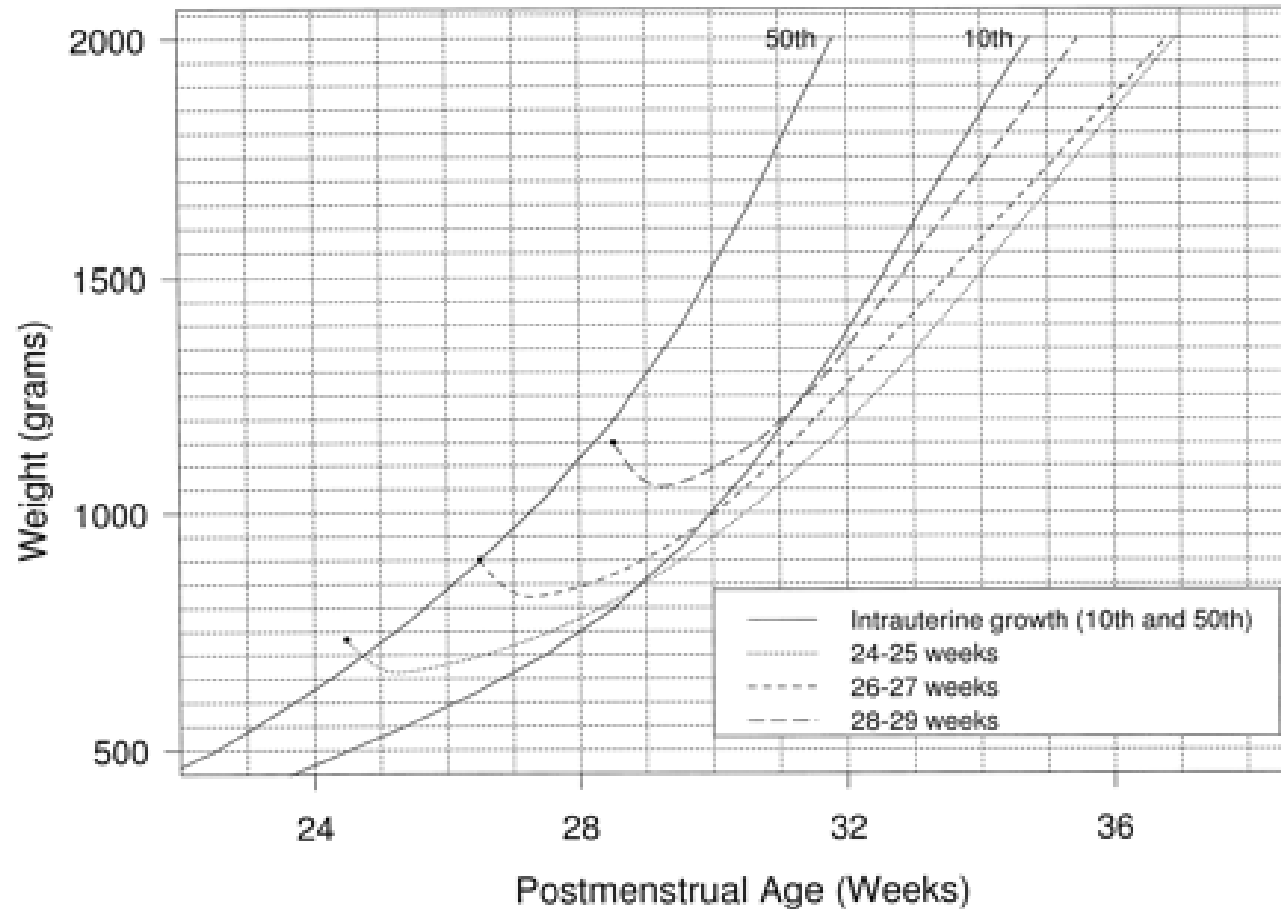
- Low birth weight, small head circumference, or decreased length for age: associated increased risk for cardiovascular disease [Barker, 1989,1993]
- Transgenerational: low maternal birthweight or HC: higher offspring blood pressure in adulthood [Fall et al., 1995]

# Programming

- Most preterm infants are AGA
- Grow poorly in the postnatal period
- Resultant “SGA” status
- Catch up growth



# Extremely Low Birth Weight Infants Grow Poorly



Average body weight compared to intrauterine growth

Ehrenkranz, Pediatrics, 1999

# Reasons for poor postnatal growth

- Expected postnatal weight loss
- Undernutrition
  - delayed commencement of TPN
  - Intolerance to glucose and lipids
  - Feeding volumes and withholding
  - Unfortified human milk or term formulas

# Best Practices for the current era

- Early aggressive parenteral nutrition
- Early enteral nutrition: either trophic or advance as tolerated but, at a slow rate
- Have guidelines for gastric residuals
- Human milk, fortified
- Age-specific formula for the premature infant
  - <1800g: 24 kcal, premature infant formula
  - 1801-2500: transitional formula

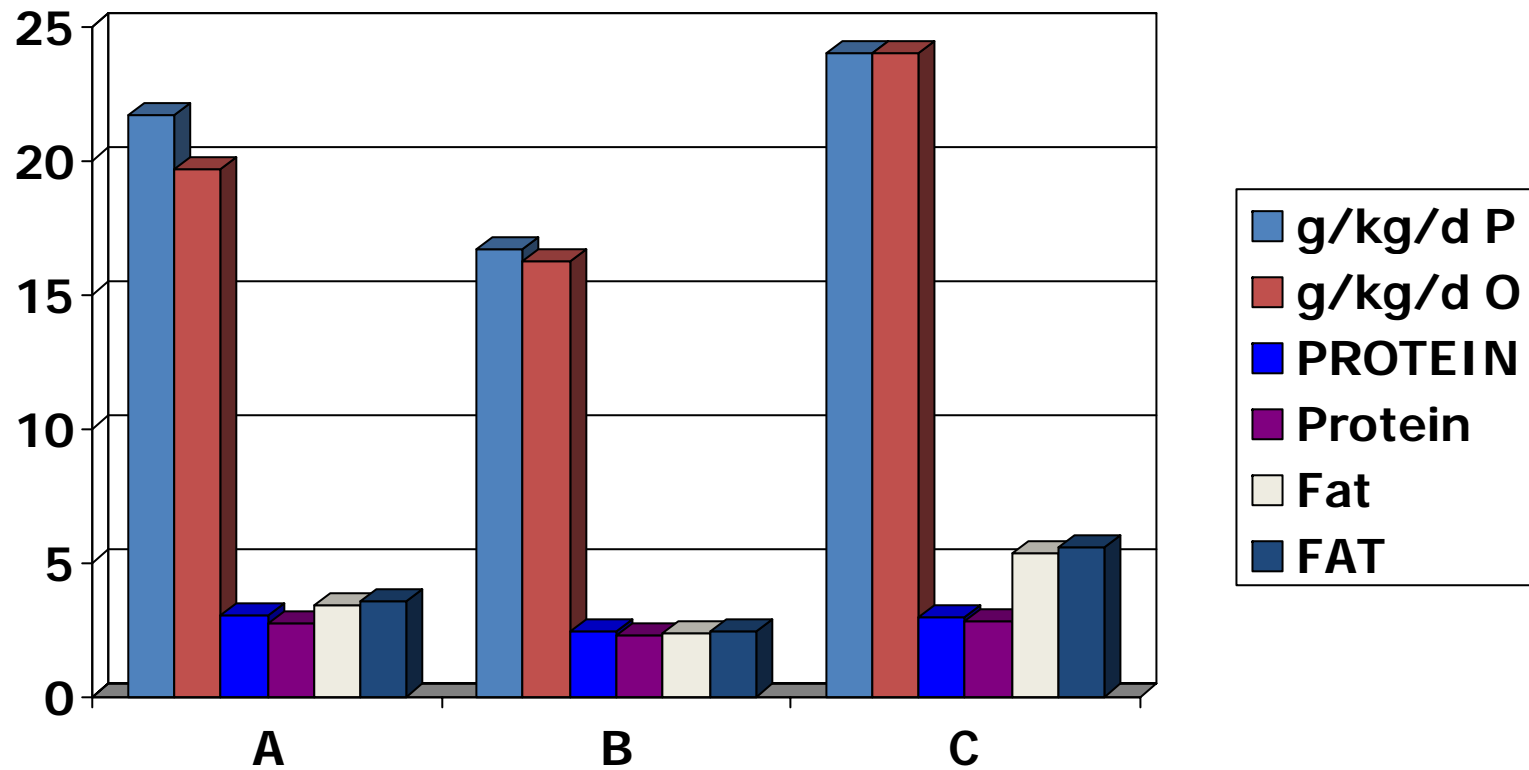
# Nutritional Intake

- Example:
- Premature infants fed a standard term formula gain 13 g/kg/d and 1.2 mm HC/d
- When fed premature infant formulas, 16.6g/kg/d and 1.53 mm/d
- 110-130 kcal/kg/d should allow for adequate growth

# Catch up growth

- Is it possible?
- Composition of weight gain
- Protein energy ratios of feedings compared to intrauterine predictions

# Catch up Growth

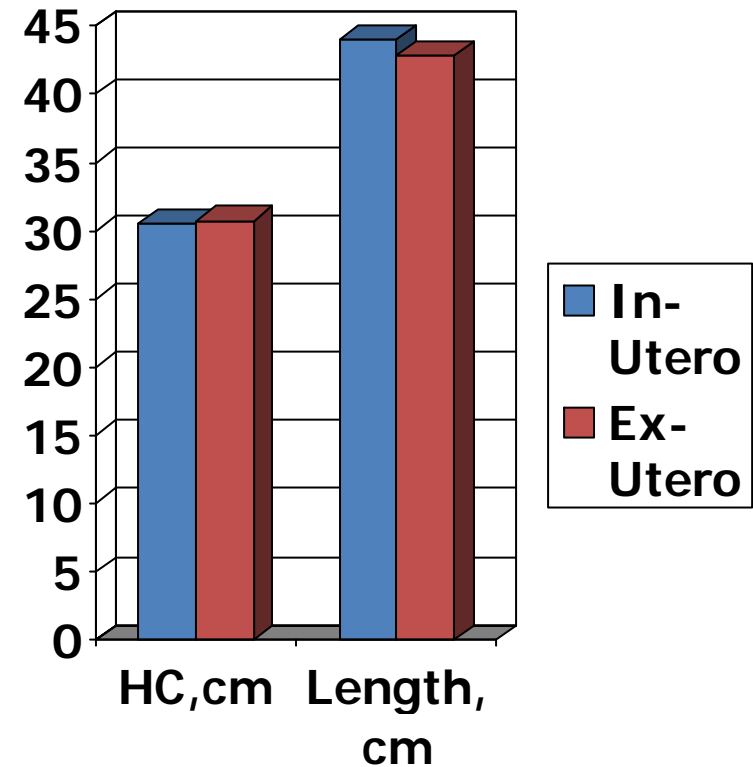
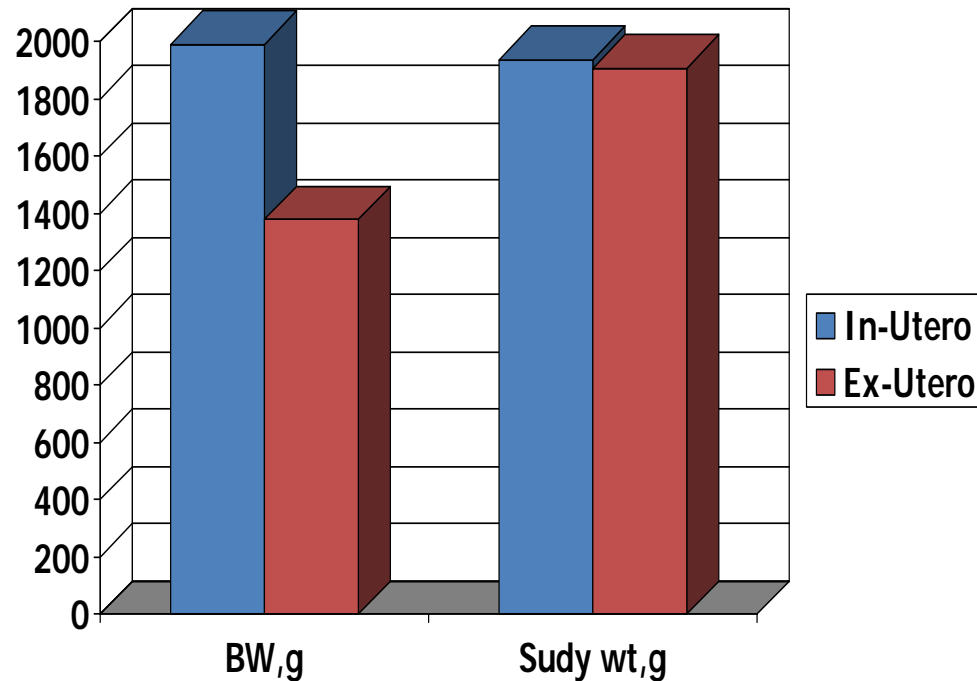


# Catch Up Growth

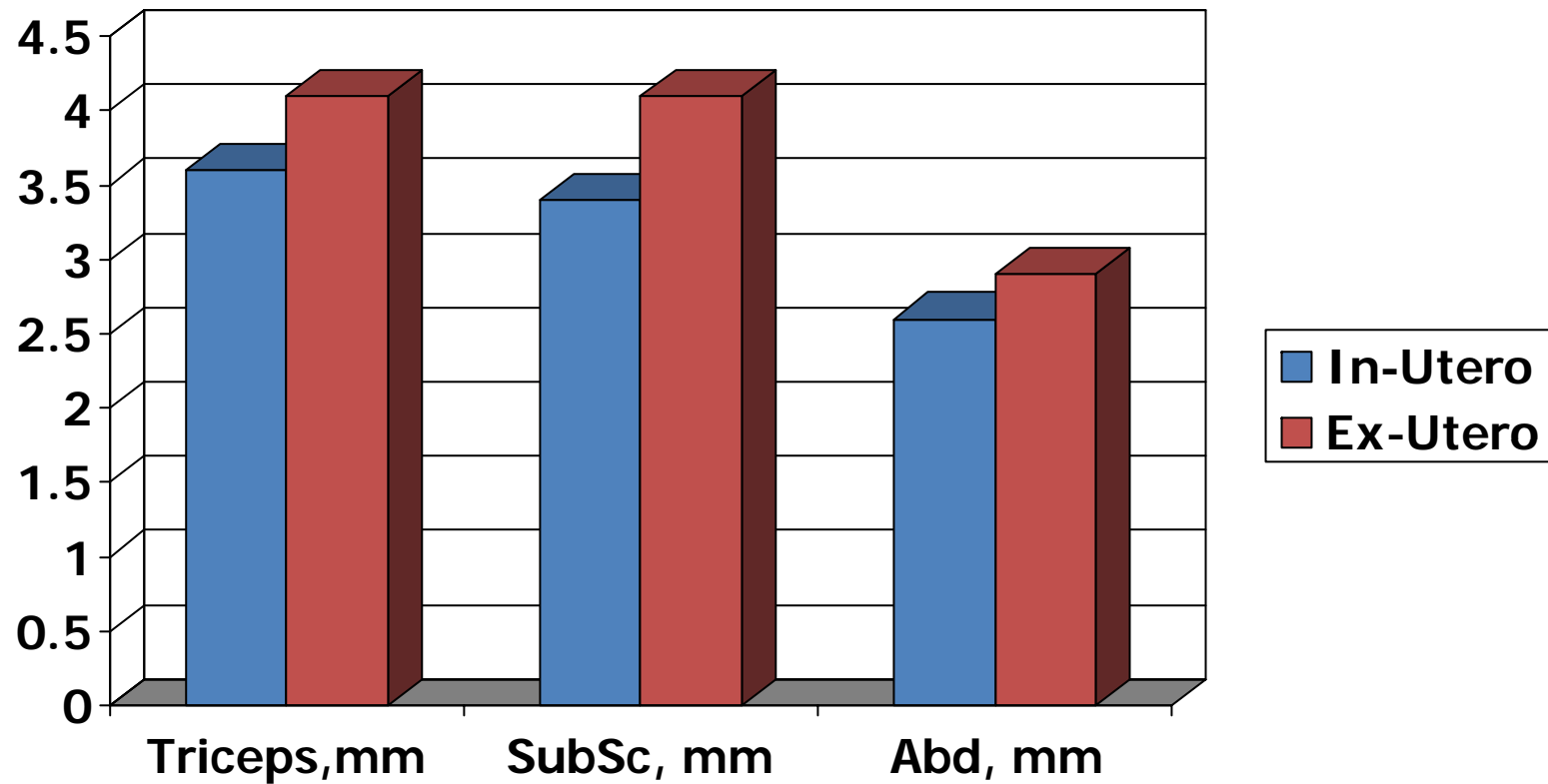
- Nearly impossible without excessive feeding or excessive fat gain
- Long-term consequences not known

# Growth “In-Utero” and “Ex-Utero”, Bhatia

et al., 1988



# Skinfold thickness, 0 sec



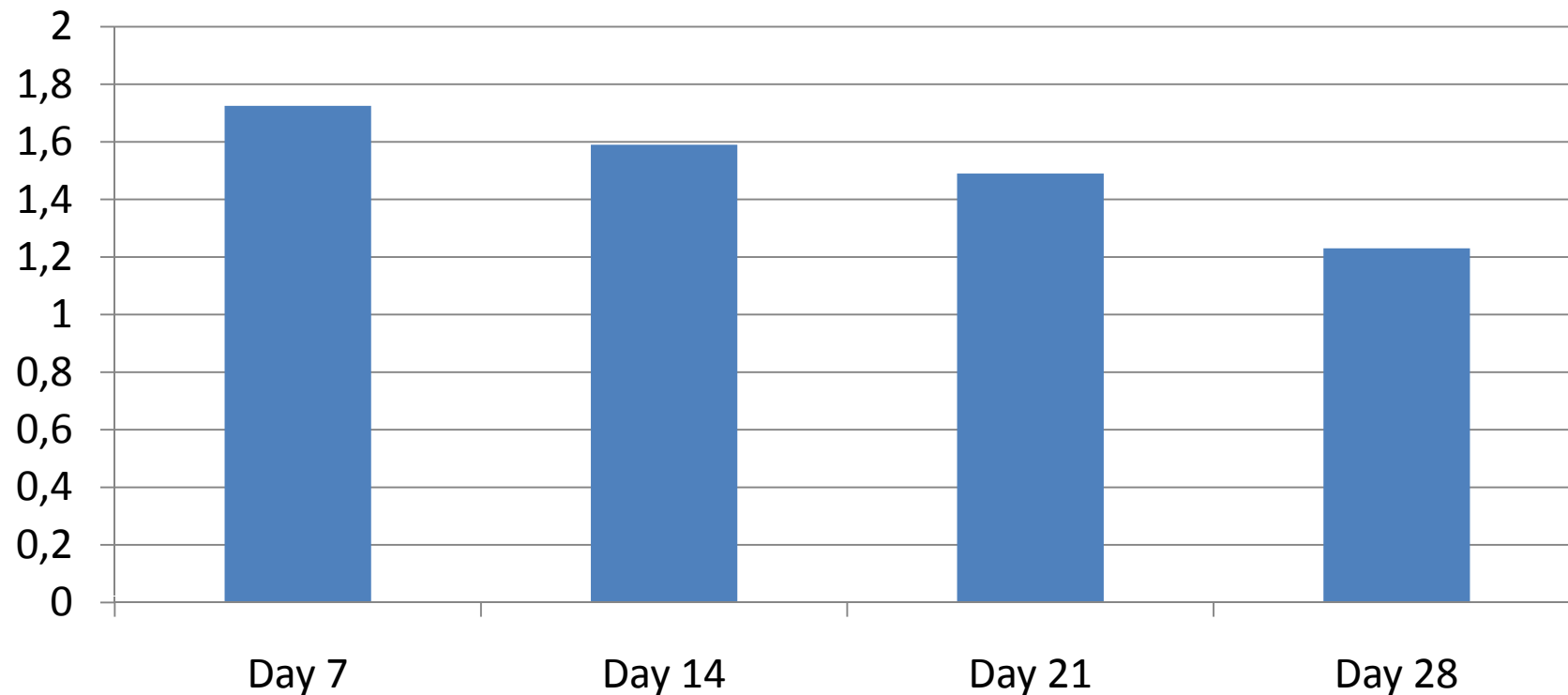
# Late Enteral Nutrition

- Match or exceed intrauterine growth
- Current generation of formulas may not meet the nutrient needs, especially protein, of the smallest infants
- Human milk **MUST** be fortified: protein, Ca, Phosphorus, sodium, energy, zinc, iron

# Protein Content of Preterm Human Milk

Lemons et al., Pediatr Res 1982

Protein, g/100mL



# Protein Levels in Fortified Preterm Human Milk

	g/100 Calories	g/150 mL
Protein in unfortified milk <sup>1</sup>	2.1	2.1
1 packet powdered HMF + 25 mL PTHM	2.97	3.5
1 vial liquid HMF + 25 mL PTHM	4	4.8
PTHM + 30 calorie PTF [1:1]	2.64	3.3

Schanler RJ, Atkinson SA. In: Tsang RC, et al, eds. Nutrition of the Preterm Infant. 2nd ed. Digital Educational Publishing; 2005.

# Assumed vs. Actual intakes

	<u>Protein intake (g/kg/d)</u>	
	<u>Assumed</u>	<u>Actual</u>
Week 1	3.6	2.9
Week 2	3.7	3.1
Week 3	3.8	3.1

Data of Arslanoglu, Moro & Ziegler, J Perinatology 2009; 29:489

# Solutions to the problem of inadequate protein fortification of breast milk

## In addition to commercial fortifier:

1. Add more fortifier
2. Add more protein
3. Targeted fortification
4. Add protein based on blood urea (BUN)  
("adjustable fortification")

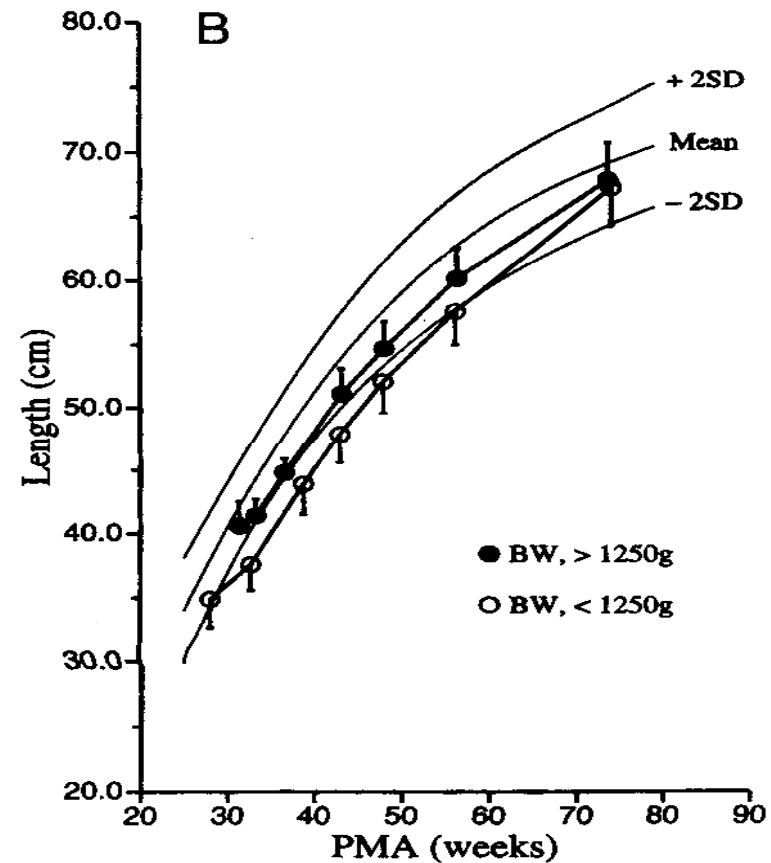
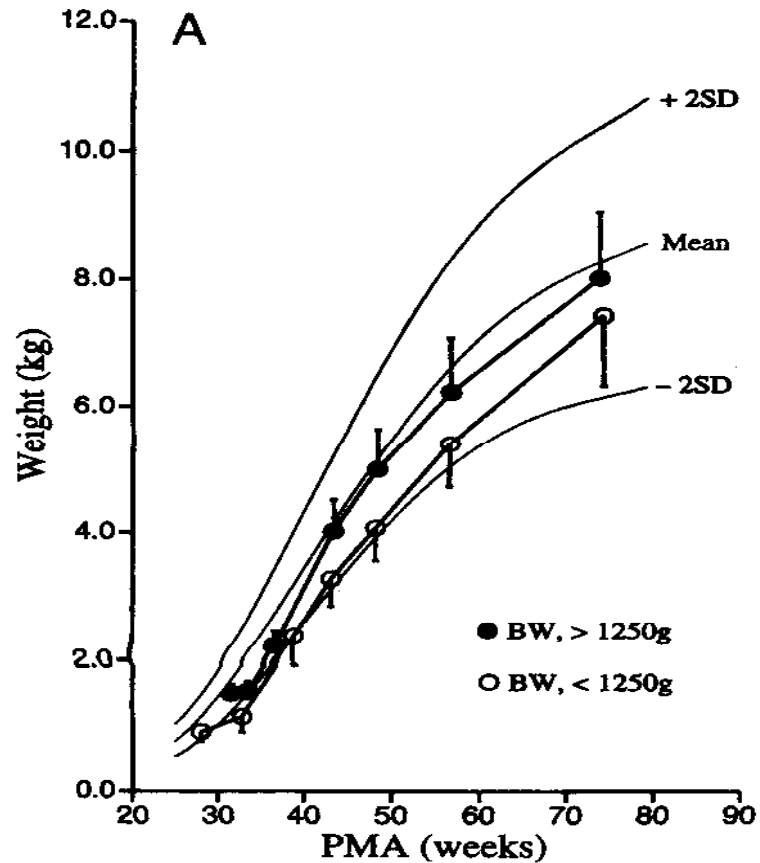
# Approaches to Intervention

- Specially designed “post-discharge” formulas or preterm formulas
- Lucas et al. Randomized infants <1850g to either standard term formula or a post-discharge formula
- Higher bone mineral content, better weight, length and head circumference

# Approaches to Intervention

- Lucas et al. Term or post-discharge formula for 9 months
- Weight was greater at 9 months but not at 18 months
- Length was greater at 9 and 18 months
- No differences in head circumference
- No differences in outcomes
- Growth benefits limited to males!

# Growth with Preterm Formulas

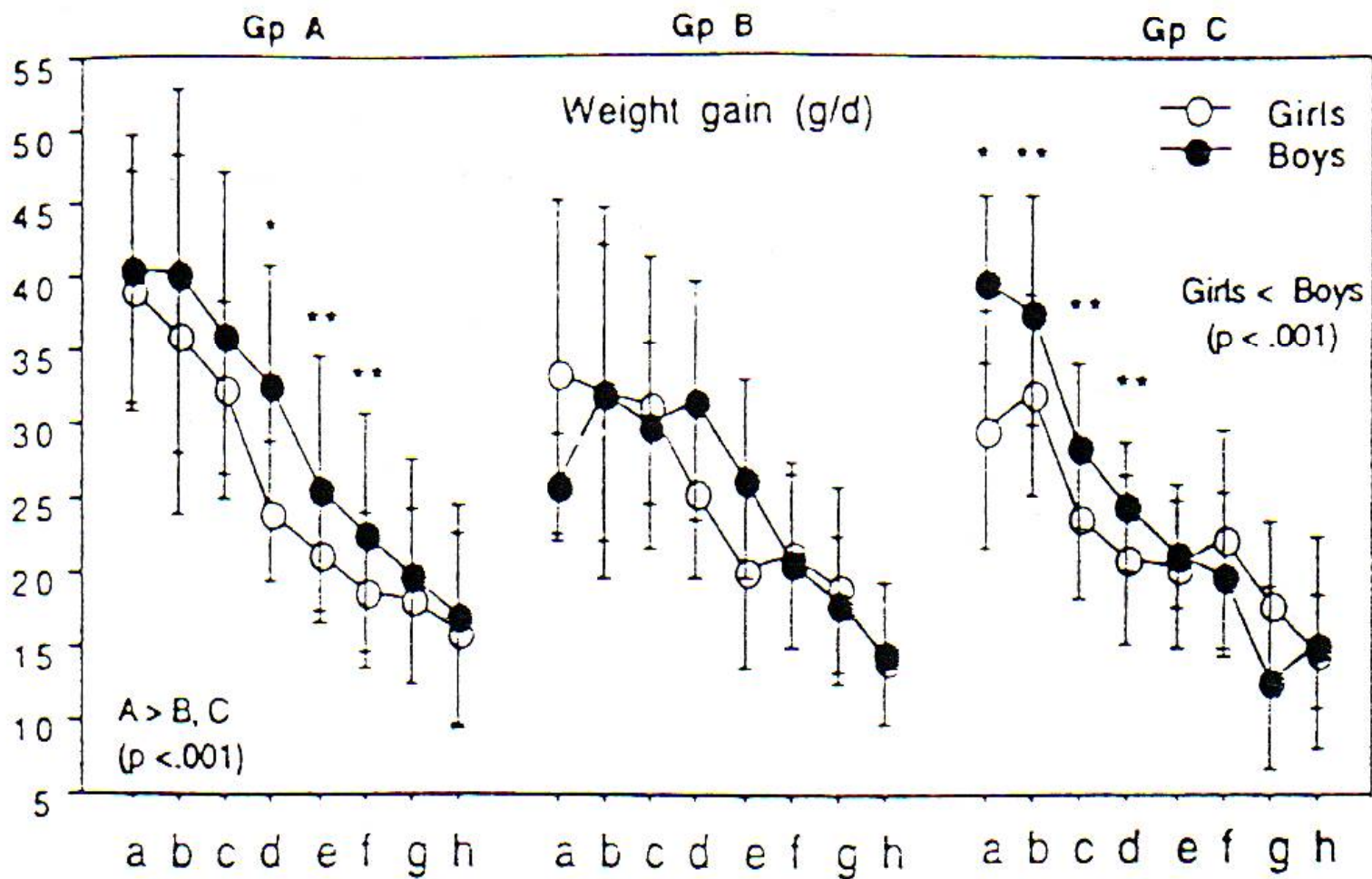


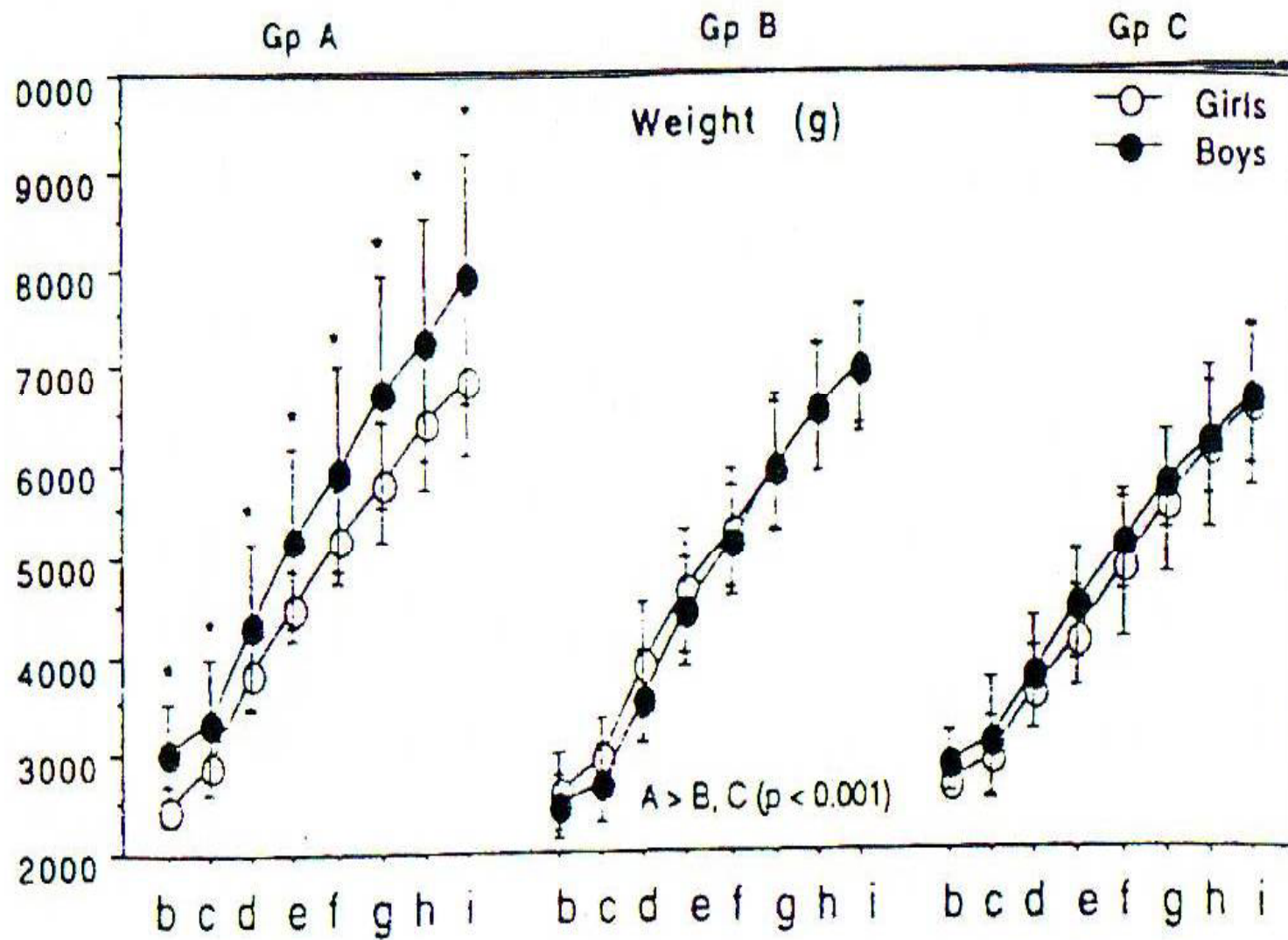
# Approaches to Intervention

- Cooke et al. Randomized to preterm formula until 6 months post conception OR preterm until expected date of delivery and then term formula OR term formula for 6 months
- Down regulated intake to achieve similar energy intakes
- Higher protein, zinc, vitamin and mineral intakes
- Boys: weight, length, HC were greater in preterm formula group and persisted at 18 months

# Approaches to Intervention

- Infants fed preterm formula had better growth compared to fortified human milk fed infants
- No differences in developmental outcome
- Breastfed after discharge: lower serum PO<sub>4</sub>, alkaline phosphatase, transferrin
- Lower bone mineral mass, poorer growth and higher fat mass in the first year





# Therefore

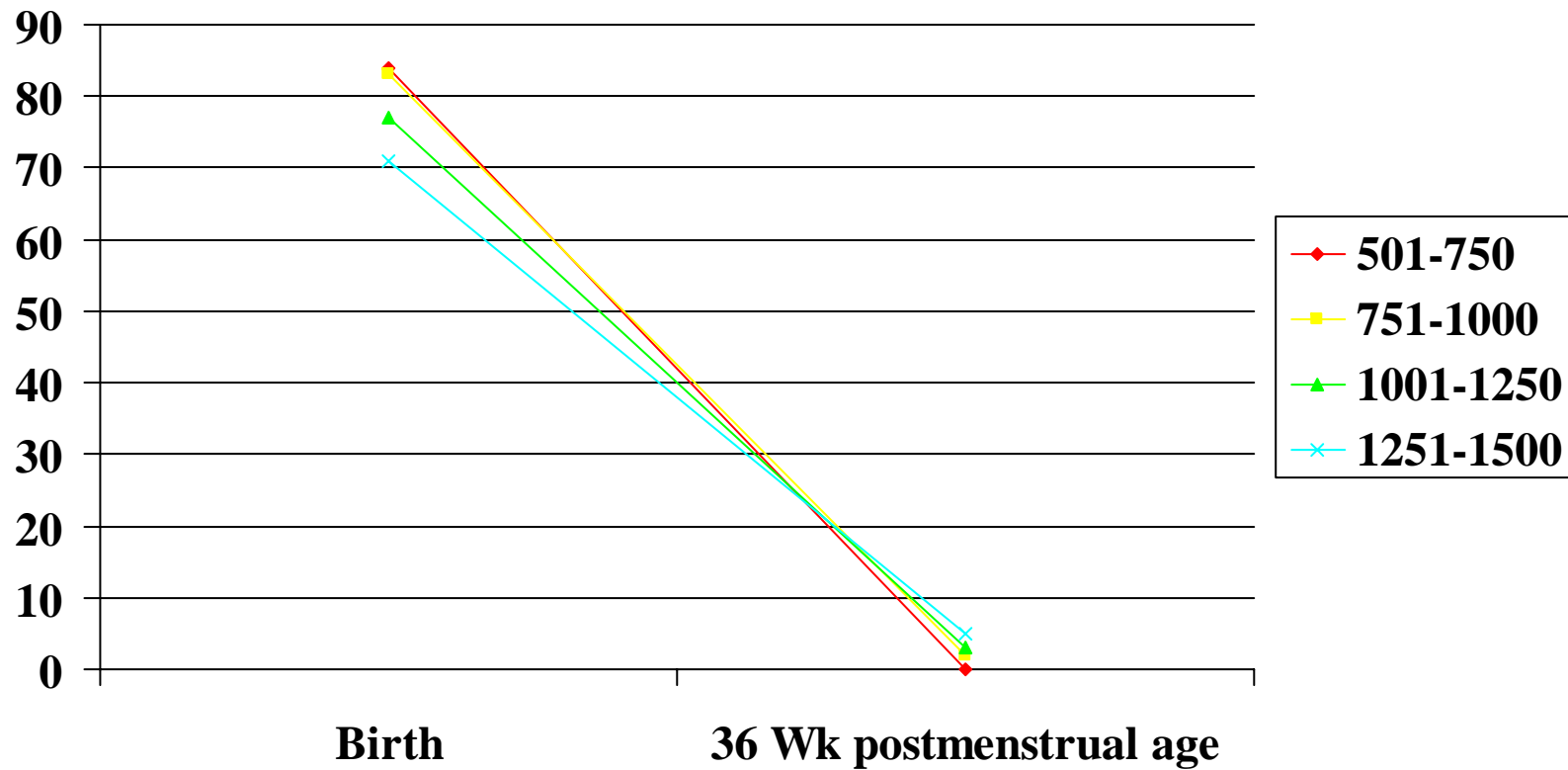
- Preterm infant formulas
- Transitional formulas
- Fortified human milk

# Post-Discharge Nutrition and Growth

Pediatrics 2008, JPGN 2009

- 39 LBW infants [2004-2005]
- Randomly assigned at discharge to fortified human milk or control
- Fed for 12 weeks, follow-up 1 year
- At 12 weeks significant improvement of length and head circumference, no change in weight
- At 1 year, increased length and bone mineral content, increased HC in <1250g

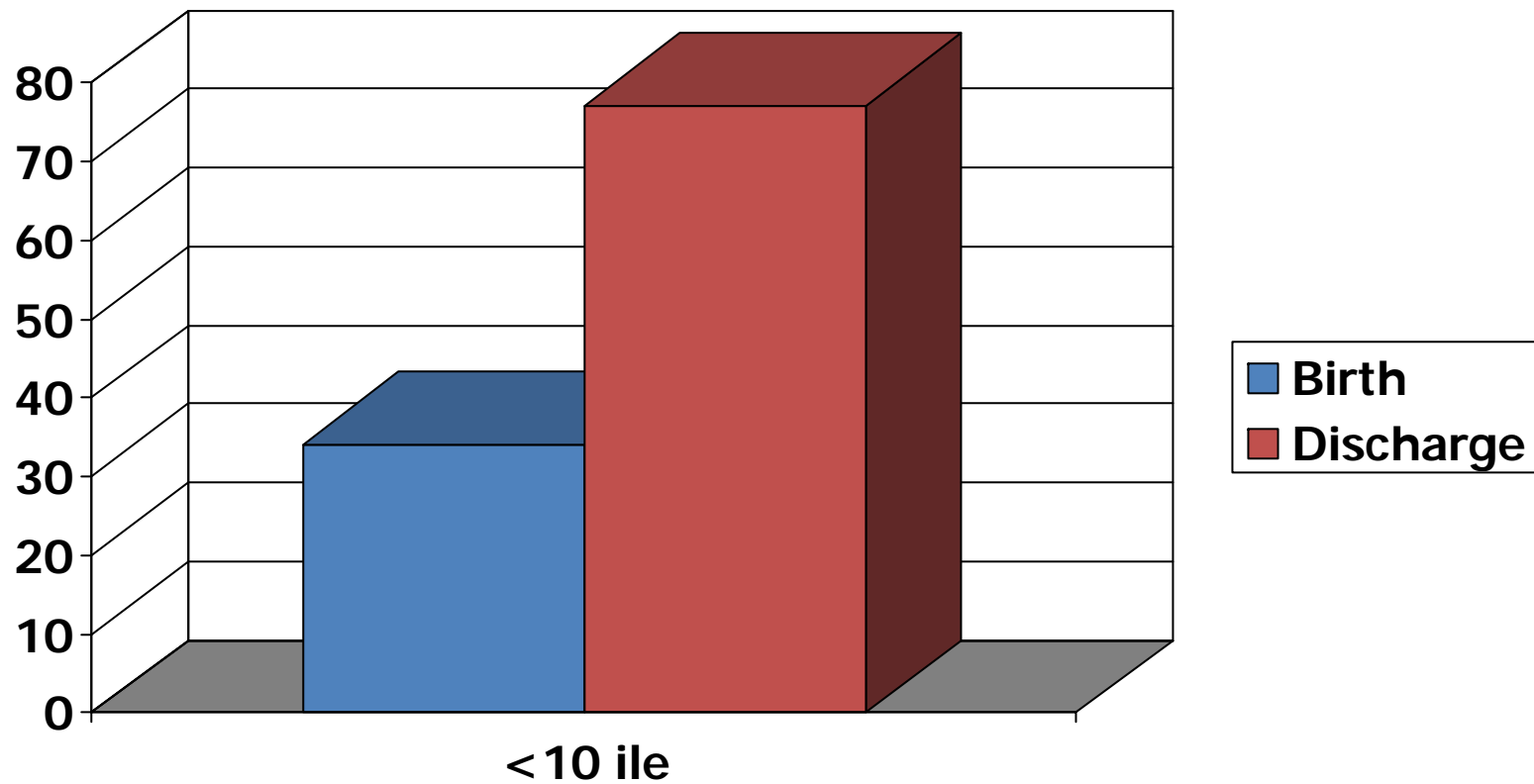
# Incidence of Normal Body Weight\* Among Very Low Birth Weight Infants



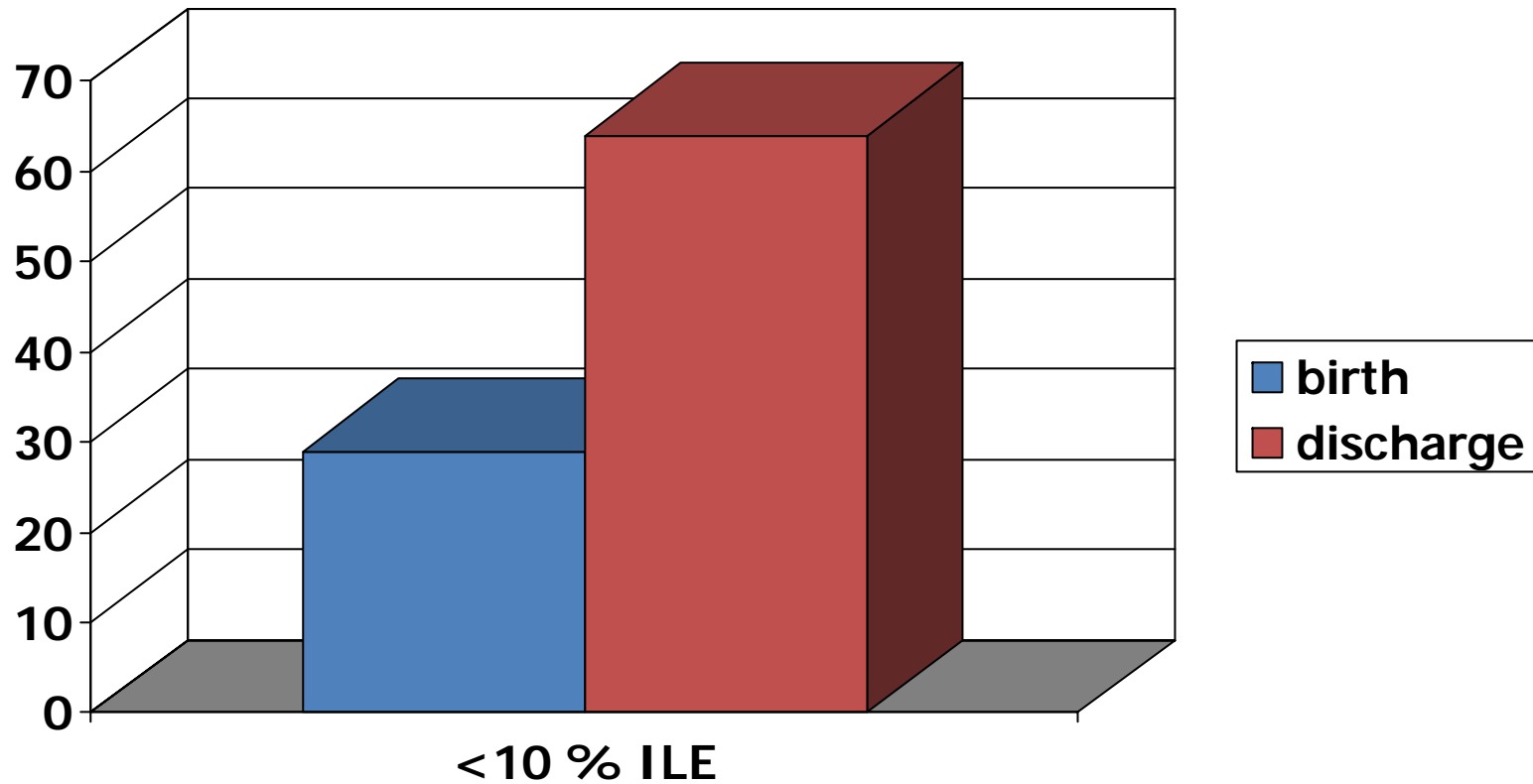
\*Above the 10<sup>th</sup> percentile

Adapted from Lemons, Pediatrics, 2001

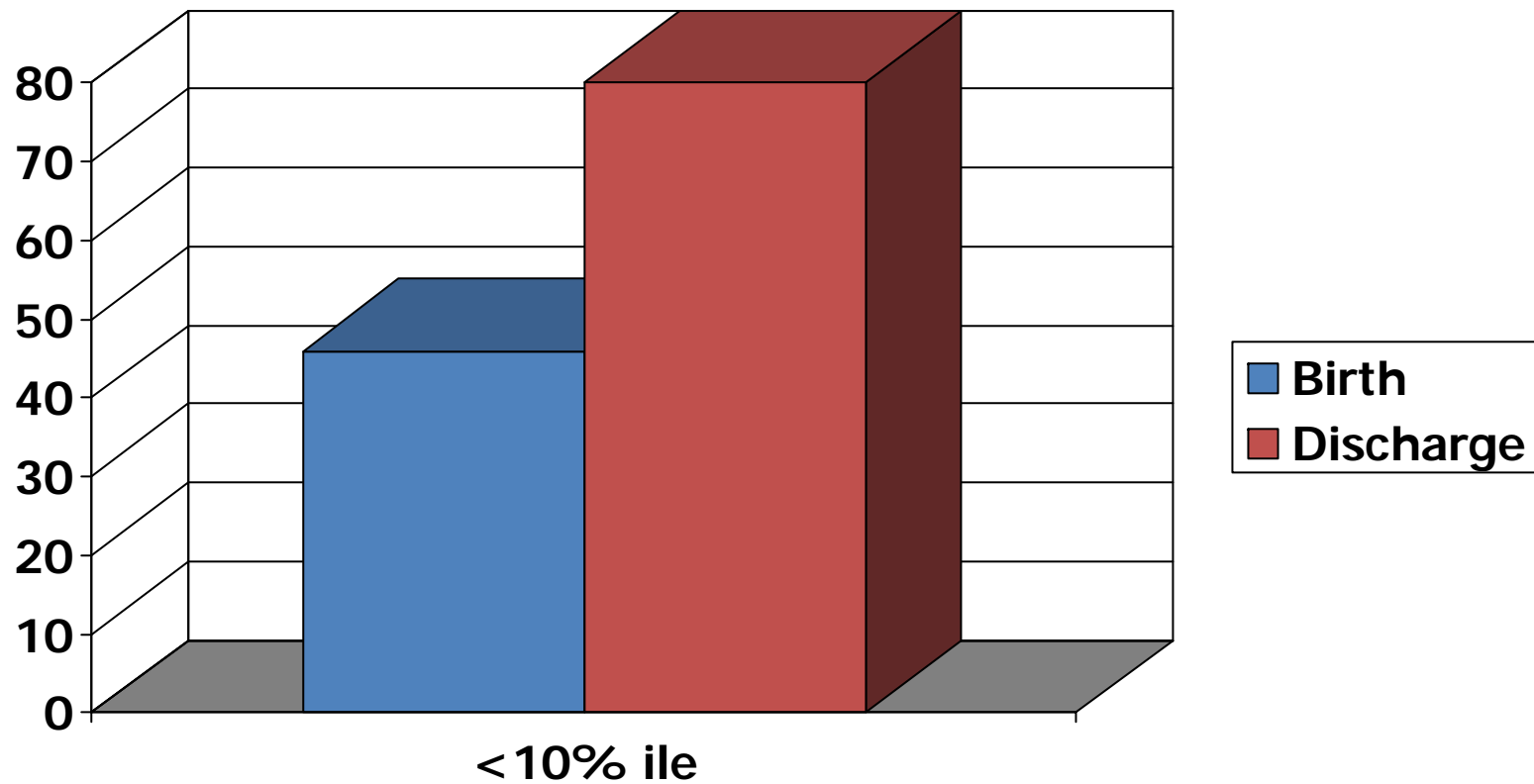
# Post Discharge Growth 1982-85



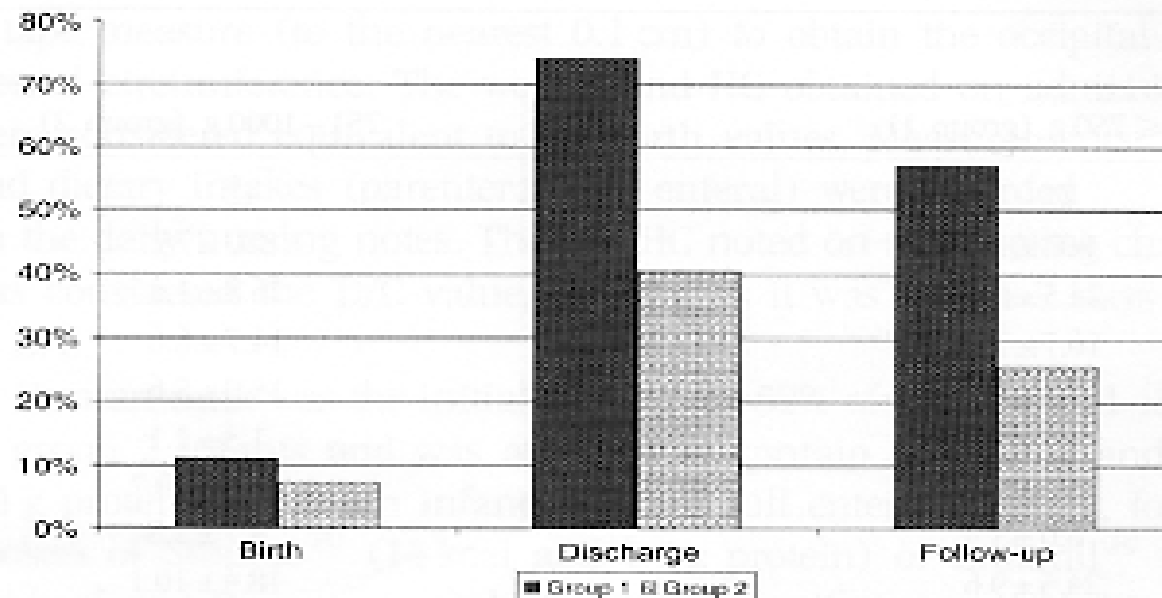
# Post Discharge Growth 1989-91



# Infants < 1000g

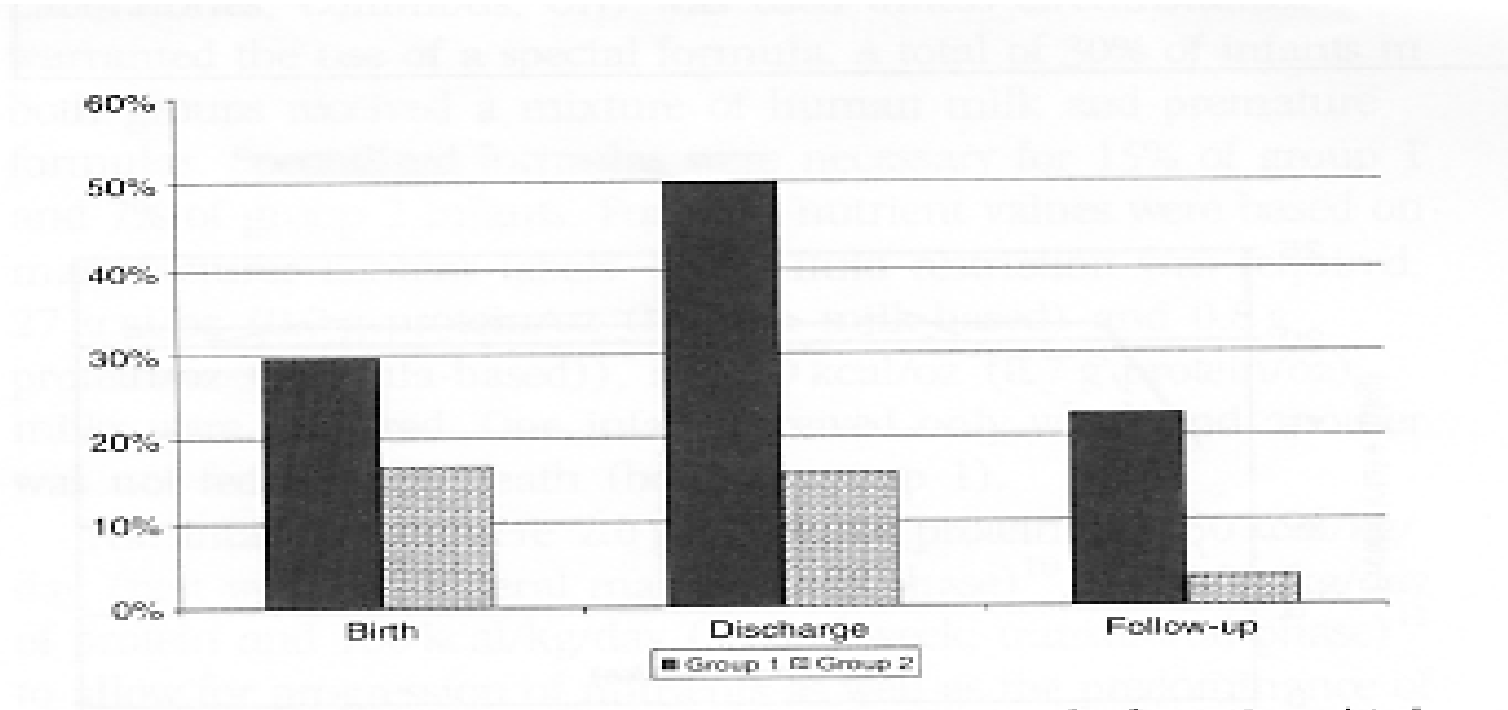


# Postnatal Malnutrition - Ernst et al., 2003



**Figure 3.** Comparison of infants < 10th percentile for weight at birth, discharge, and follow-up showing extrauterine growth retardation during hospitalization with catch-up growth postdischarge.

# Postnatal Malnutrition - Ernst et al., 2003



**Figure 4.** Comparison of infants <10th percentile for HC at birth, discharge, and follow-up showing the same pattern as for weight.

# Infants with Chronic Lung Disease

- After discharge, these infants do not always receive the intensive nutritional assessment and intervention
- 73% of infants in one study demonstrated weight decrease between discharge and 7 months
- Feeding enriched formula: improved length, lean mass, higher bone mineral content

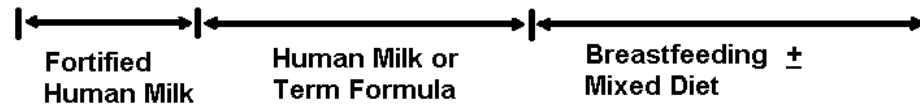
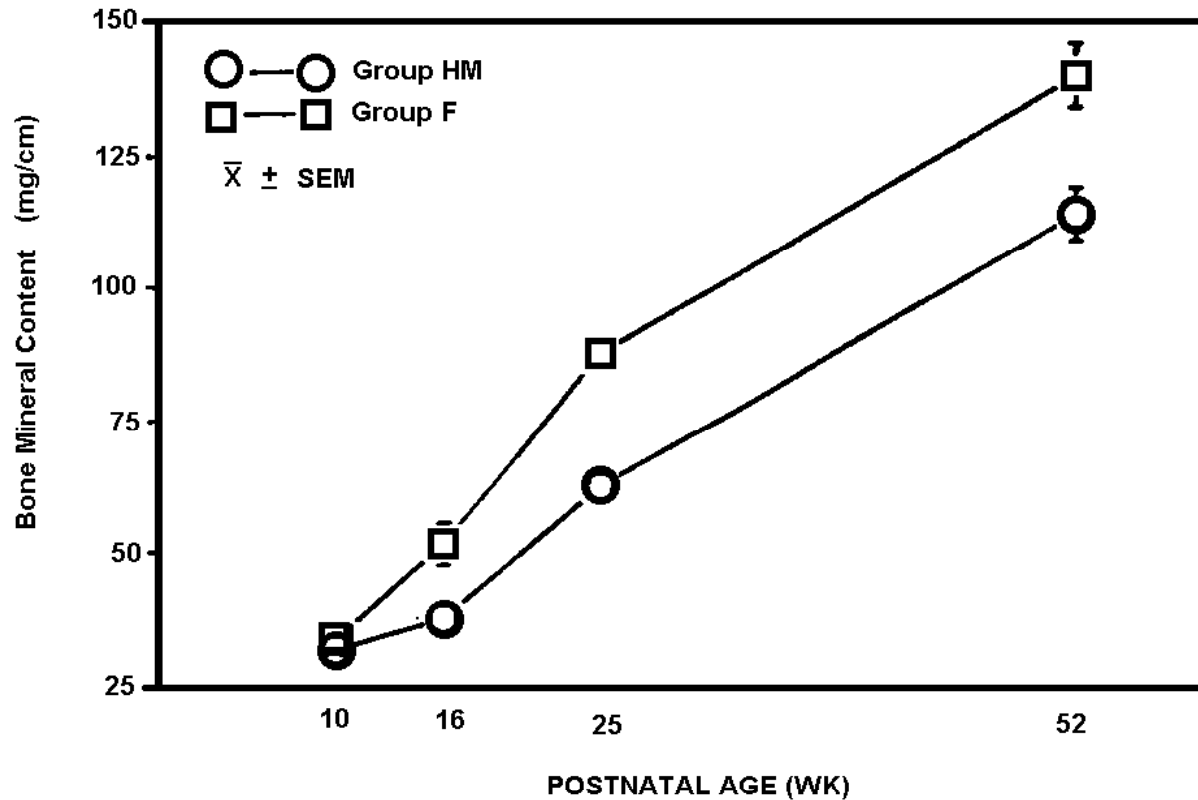
# Iron

- Growing fetus accumulates iron at a rate of 1.6-2.0 mg/kg/d
- Lower iron stores in growth restriction, diabetes, fetal losses
- Frequent blood sampling
- 6-?10 mg/kg/d iron
- Standard formulas will provide 2 mg/kg/d when fed at 150 mL/kg/d

# Osteopenia

- Calcium and phosphorus deficiency
- Fetus accumulates large quantities in third trimester
- Ca: 200 mg/kg/d, P 100 mg/kg/d
- Premature infants fed premature infant formulas until 6 months of age were longer than their term formula-fed counterparts

# Bone Mineral Content

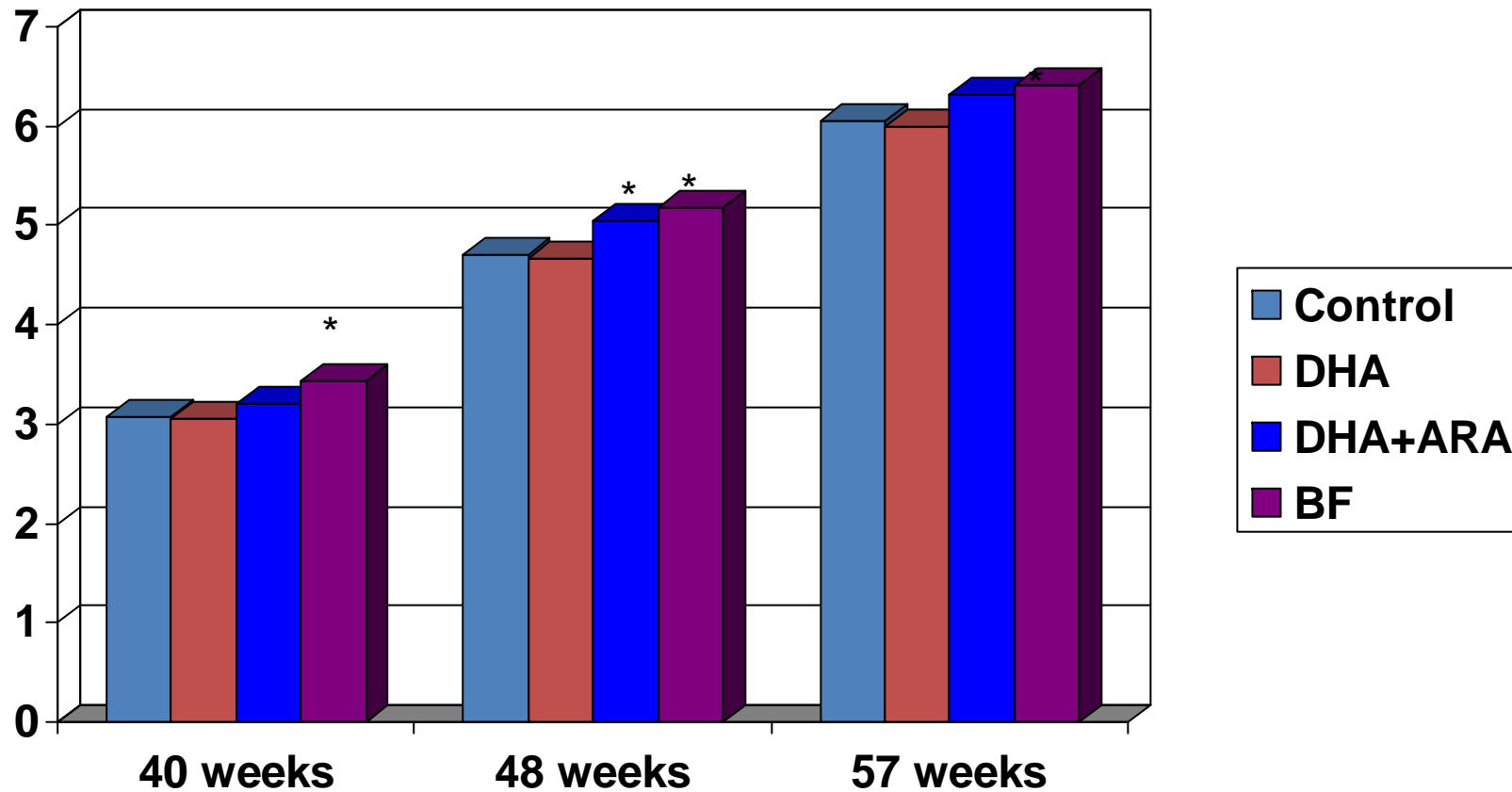


# Growth in Preterm Infants

Innis et al 2002

- Preterm infants fed DHA, DHA and ARA or control and discharged on term formula without DHA
- Compared to breast-fed term infants
- Mean GA 29-30 weeks
- Mean BW 1230-1280g

# Weight Innis et al., 2002





# Human Milk and IQ

- Exclusively breast-fed premature infants had an IQ score 10% higher than formula-fed counterparts
- ? Supplementing human milk could enhance growth while maintaining IQ advantage
- Fortification of human milk remains a challenge
- Increasing use of donor milk
- Inadequate protein intake remains reason for growth failure

# Guidelines for feeding preterm infants

- < 1800g: 24 kcal/ounce preterm formula or fortified human milk
- Transition to 22 kcal/oz >1800g or fortified human milk, all growth parameters are 25% or above and gaining 15-40g/d
- Transition from 22 to 20 kcal/ounce term formulas or human milk at 4-6 months CGA, all growth parameters above 25%

# Recommendations

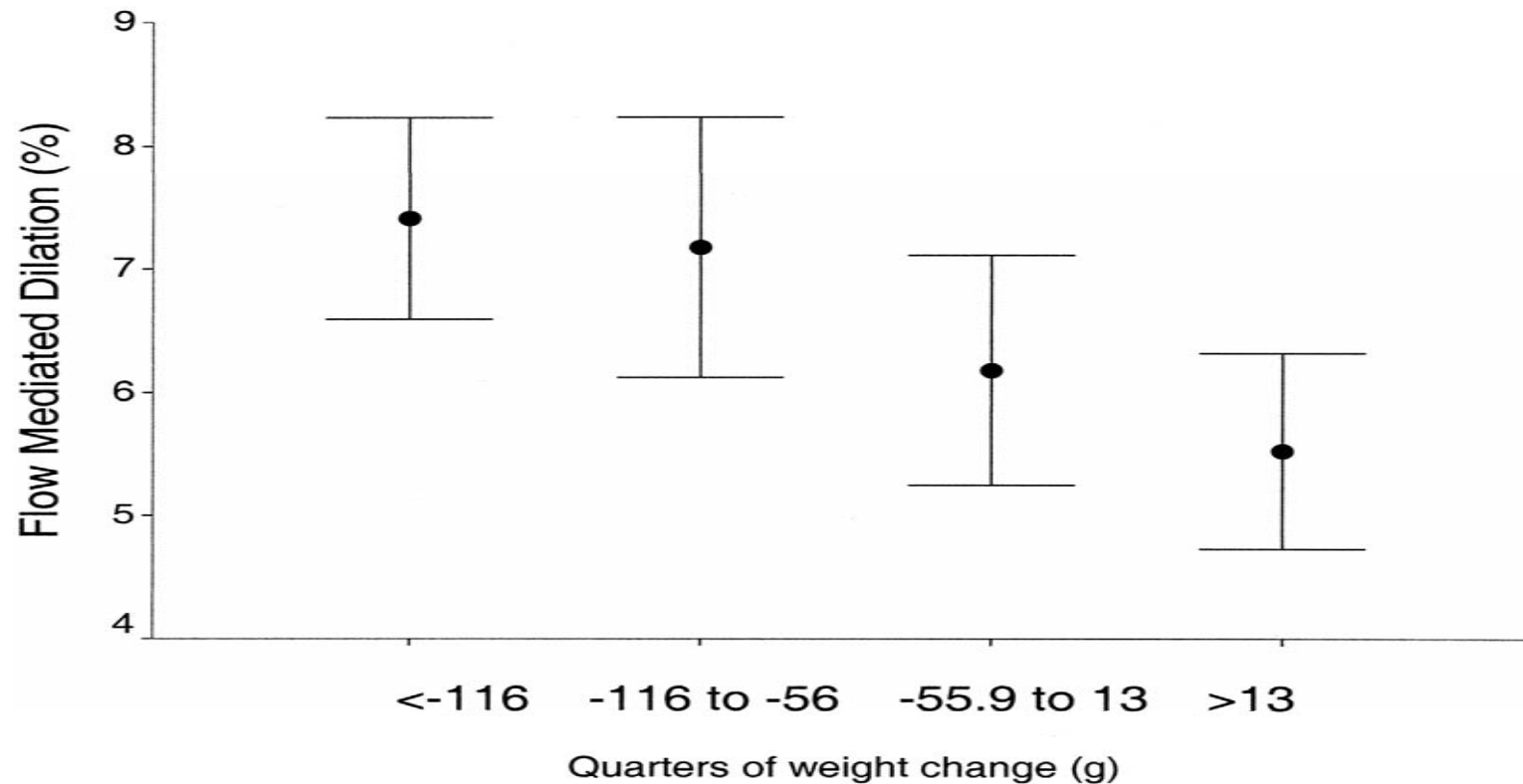
- Growth assessment and recognition of failure to thrive
- Iron supplementation
- Attention to energy intakes and growth
- Achieve the best possible gain without adverse effects

# Is slower growth beneficial?

[Singhal et al., 2004]

- Accelerated neonatal growth increases the later incidence of cardiovascular disease
- Cohort of preterm infants who had been part of a longitudinal investigation studied [216 out of 926] at 13-16 years
- Brachial artery flow-mediated endothelium-dependent dilation [FMD]
- Resting and hyperemic blood flow velocities determined

# FMD in Adolescence



# Singhal et al., 2004, contd

- No statistically significant differences in FMD between children born preterm and fed different feedings
- FMD in children with weight gain in the first two weeks of life greater than sample mean was lower than those with weight gain below the mean [p=0.0003]; also different from term controls
- A greater rate of weight gain during the 2 week window was associated with endothelial dysfunction in adolescents

# Nutrition and the Preterm Infant

- Optimal growth and requirements remain to be defined
- At least for now, the guidelines provided should be followed
- Long term strategies for feeding required