

Is Breastfeeding Protective Against Childhood Obesity?

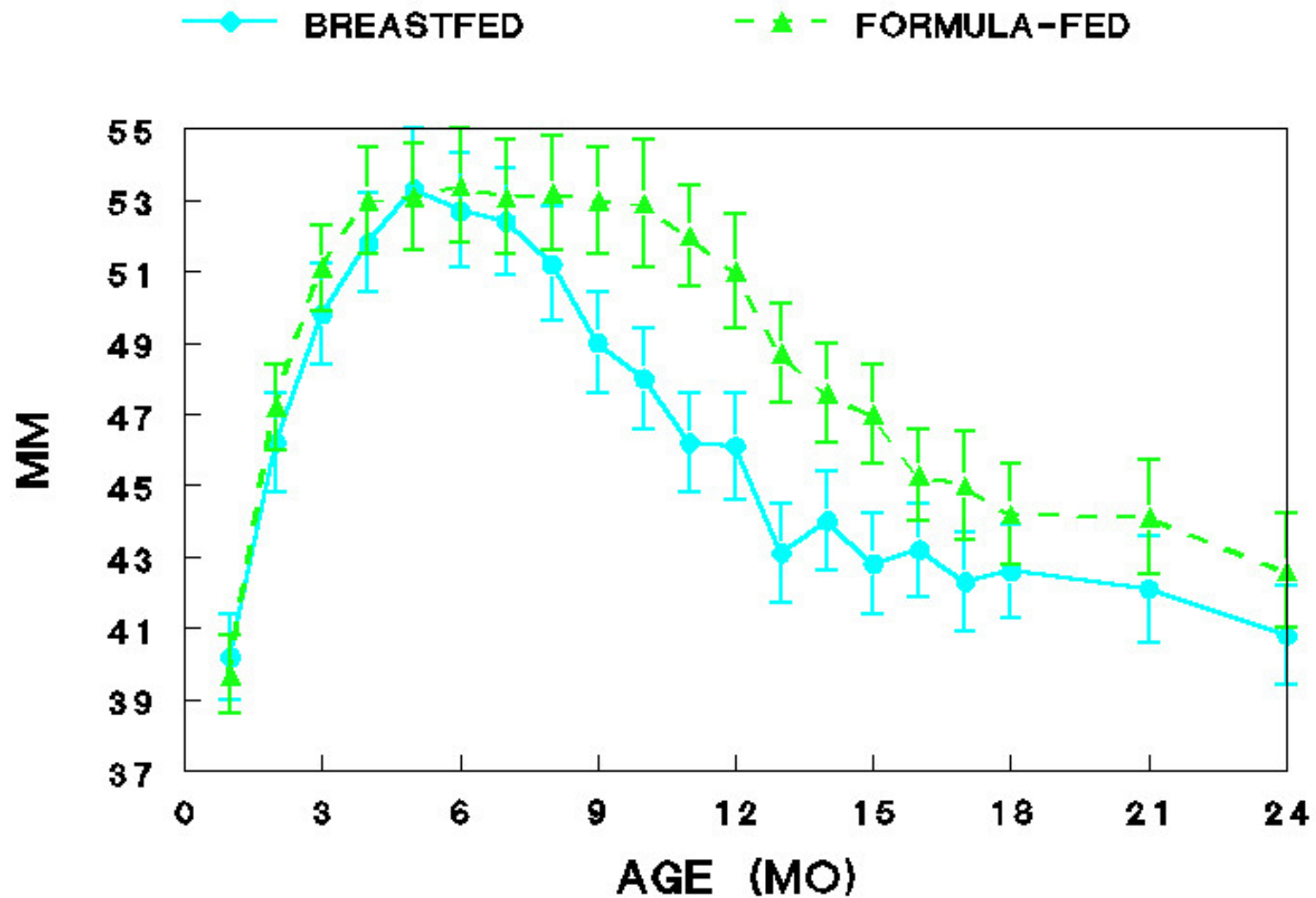
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Growth patterns during infancy

DARLING Study

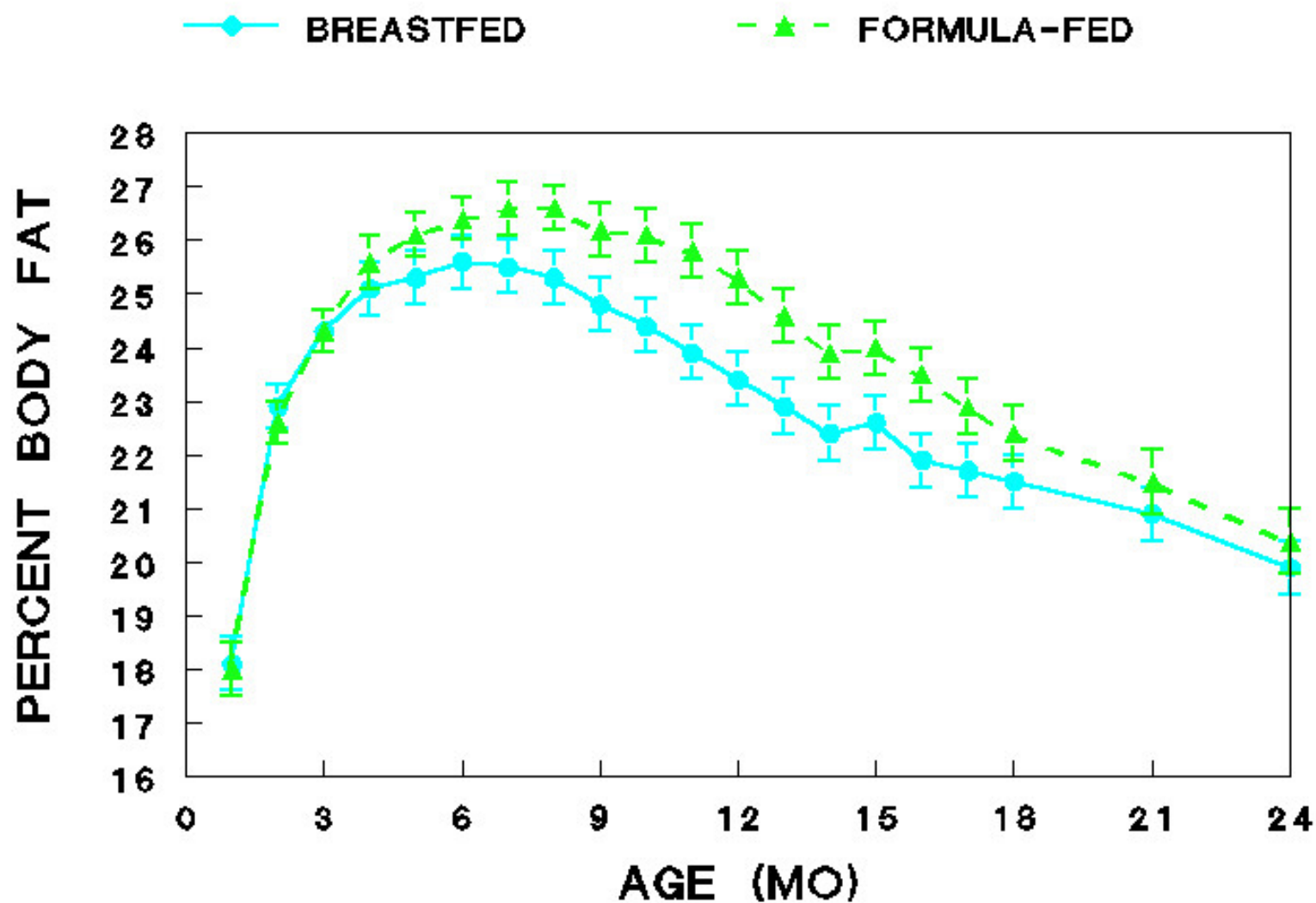
- Davis Area Research on Lactation, Infant Nutrition and Growth (1986-1990)
- Longitudinal study, 0-24 mo, of growth, intake, morbidity and development of matched cohorts of infants either breastfed (N=46) or formula-fed (N=41) until ≥ 12 mo of age

SUM OF SKINFOLDS



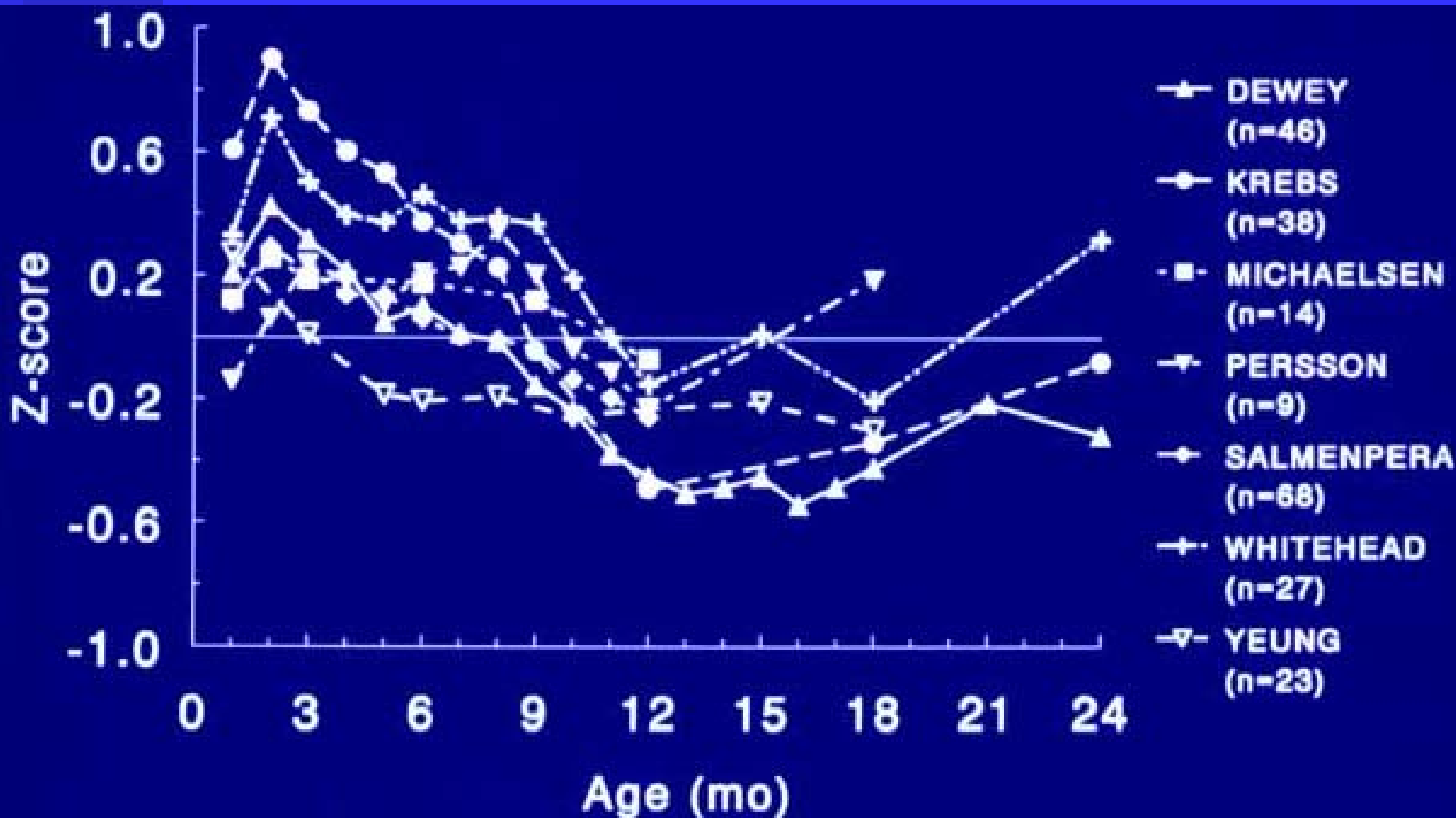
BF vs FF, $p < 0.05$ at 9-17 mo

PERCENT BODY FAT



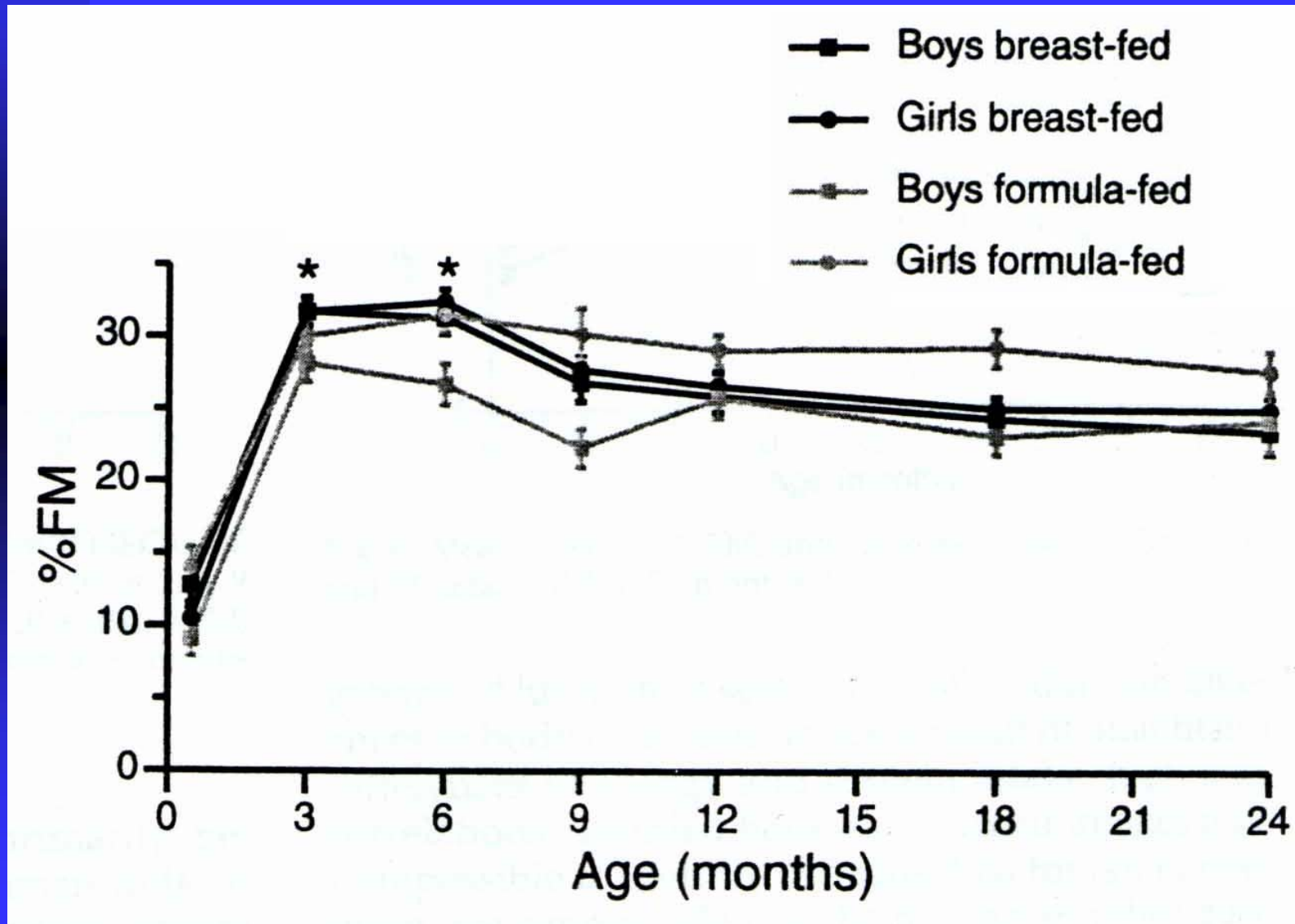
BF vs. FF, $p < 0.05$ at 5-24 mo

Mean weight-for-length z-score of infants breastfed at least 12 mo



Butte et al. (2000)

% Body fat of BF and FF infants



Association of breastfeeding with obesity later in life

Study selection criteria:

- $N \geq 100$ per feeding group
- Age at follow-up > 3 y
- Outcome = % overweight or obese

Studies in preschool children

[yellow = covariates include maternal BMI]

Author, year, site	N, age	Feeding groups	Outcomes	Results [*p < 0.05]
Armstrong, 2002, Scotland	32,200 3-4 y	EBF vs. EFF at 6-8 wk	BMI > 95 th BMI > 98 th	AOR 0.72* AOR 0.70*
Bogen, 2004, USA	73,458 4 y	BF < 8 wk, 8-15 wk, 16-26 wk, > 26 wk (+/- concurrent FF)	BMI ≥ 95 th	AOR 0.71 for 16-26 wk w/o FF*
Hediger, 2001, USA	2,685 3-5 y	Ever BF vs. EFF (+ dur. full BF)	BMI 85-94 th BMI ≥ 95 th	AOR 0.63* AOR 0.84
Grummer-Strawn, 2004, USA	177,304 (12,587) 4 y	BF < 1, 1-3, 3-6, 6-12, or ≥ 12 mo, vs. EFF	BMI ≥ 95 th	AOR for White, non-Hisp 0.70* (6-12 mo) 0.49* (≥ 12 mo)
O'Callaghan, 1997, Australia	3,909 5 y	BF duration	BMI 85-94 th BMI > 95 th	NS

*Only among white children whose mothers did not smoke

Studies in school-aged children

[yellow = covariates include maternal BMI]

Author, year, site	N, age	Feeding groups	Outcomes	Results [*p < 0.05]
Von Kries, 1999, Germany	9,357 5-6 y	Ever BF vs. EFF (+ dur. EBF)	BMI > 90 th BMI > 97 th	AOR 0.79* AOR 0.75*
Wadsworth, 1999, UK	3,731 6 y	Ever BF vs. EFF (+ dur. BF)	BMI > 90 th BMI > 97 th	RR 0.95 RR 0.88
Bergmann, 2003, Germany	480 6 y	BF ≥ or < 3 mo	BMI > 90 th BMI > 97 th	AOR 0.53* AOR 0.46*
Toschke, 2002, Czech Republic	33,768 6-14 y	Ever BF vs. EFF, (+ duration BF)	BMI > 90 th BMI > 97 th	AOR 0.80* AOR 0.80*
Liese, 2001, Germany	2,108 9-10 y	Ever BF vs. EFF (+dur. BF, EBF)	BMI > 90 th	AOR 0.66*
Gillman, 2001, USA	15,341 9-14 y	Pred BF vs. Pred FF 0-6 mo	BMI > 95 th	AOR 0.78*

Studies in older adolescents

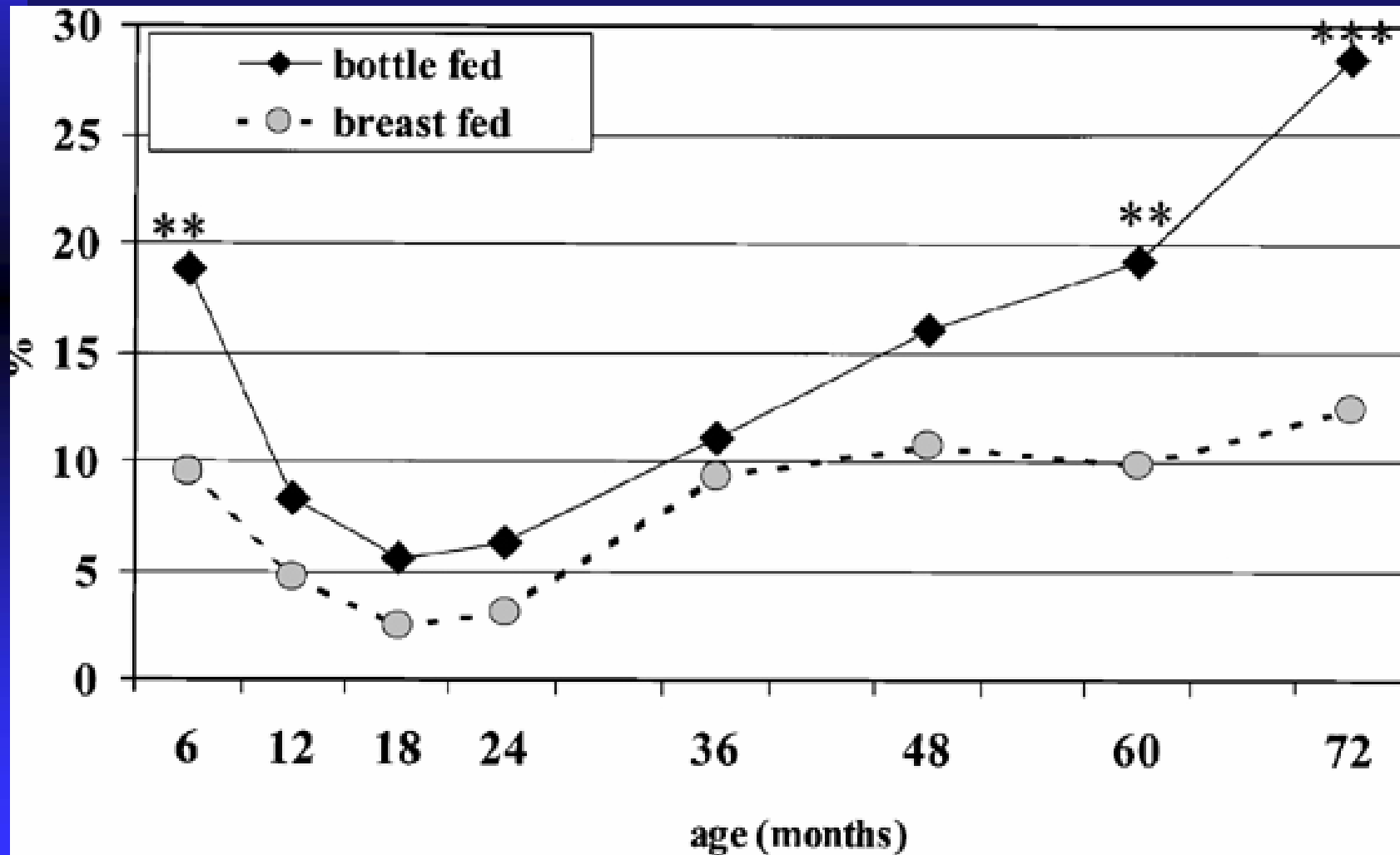
[yellow = covariates include maternal BMI]

Author, year, site	N, age	Feeding groups	Outcomes	Results [*p < 0.05]
Kramer, 1981, Canada	427 12-18y	Ever BF vs. EFF (+dur. full BF)	> 120% median weight for ht	RR 0.31*
Tulldahl, 1999, Sweden	781 17-18y	EBF > vs. ≤ 2 mo	BMI > 85 th	RR 0.70*
Poulton, 2001, New Zealand	1,037 3-26 y	BF > 6 mo vs. EFF	BMI > 25 kg/m ²	AOR 0.25-1.01
Li, 2003, UK	2,631 4-18 y	Duration BF (5 categories) vs. BF < 1 wk	BMI > 95 th	AOR 0.68-2.02
Victora, 2003, Brazil	2,250 18 y (males)	BF < 1, 1-2, 3-5, 6-8, 9-11 vs. ≥ 12 mo Pred. BF < 1, 1-2, 2-3, 3-4 vs. ≥ 4 mo	1. BMI > 85 th 2. BMI > 85 th + skinfolds > 90 th	AOR 0.85-1.34 AOR 0.38*-1.20 *(BF 3-5 mo) AOR 0.82-1.05 AOR 0.80-1.42

Bergmann et al. (Germany)

N=480; BMI at 0-6 y

Percentage of children > 90th percentile



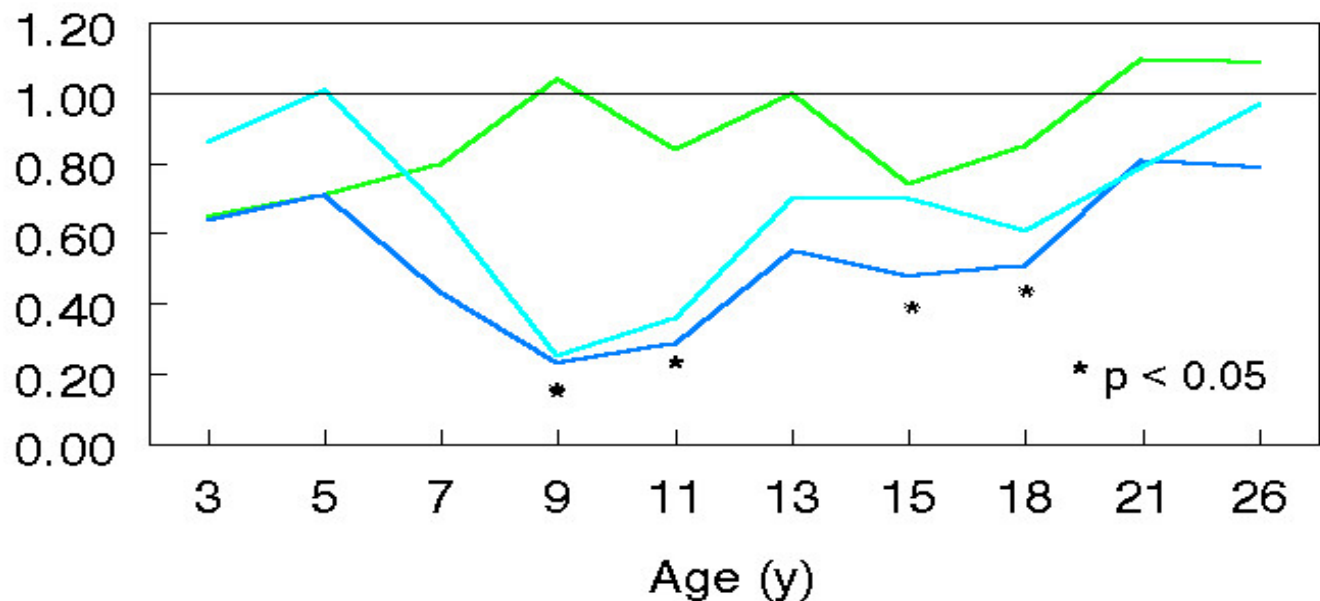
Poulton & Williams (New Zealand)

N=1,037, born 1972-73

BMI at 3, 5, 7, 9, 11, 13, 15, 18, 21, 26 y

Odds Ratios for BMI > 25 kg/m²
(EFF = 1.0)

— BF ≤ 6 mo (OR) — BF > 6 mo (OR) — BF > 6 mo (AOR)¹



¹adjusted for sex, birthwt, maternal educ., parental overweight

Is there a dose-response relationship between BF duration and lower risk of child obesity?

Yes

Bogen

Grummer-Strawn

Von Kries

Toschke

Liese

Gillman

Poulton (trend)

No

Hediger

O-Callaghan

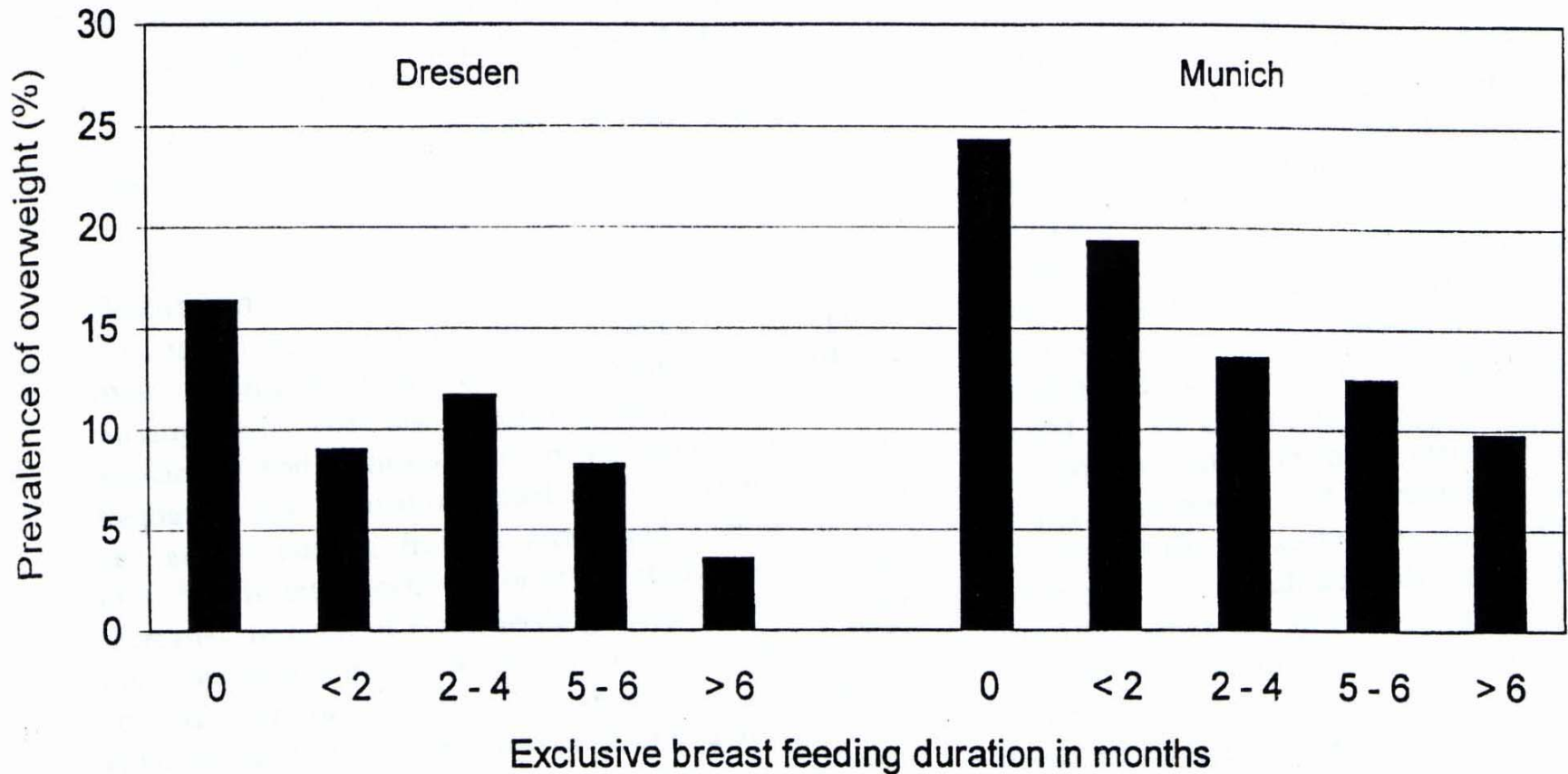
Wadsworth

Li

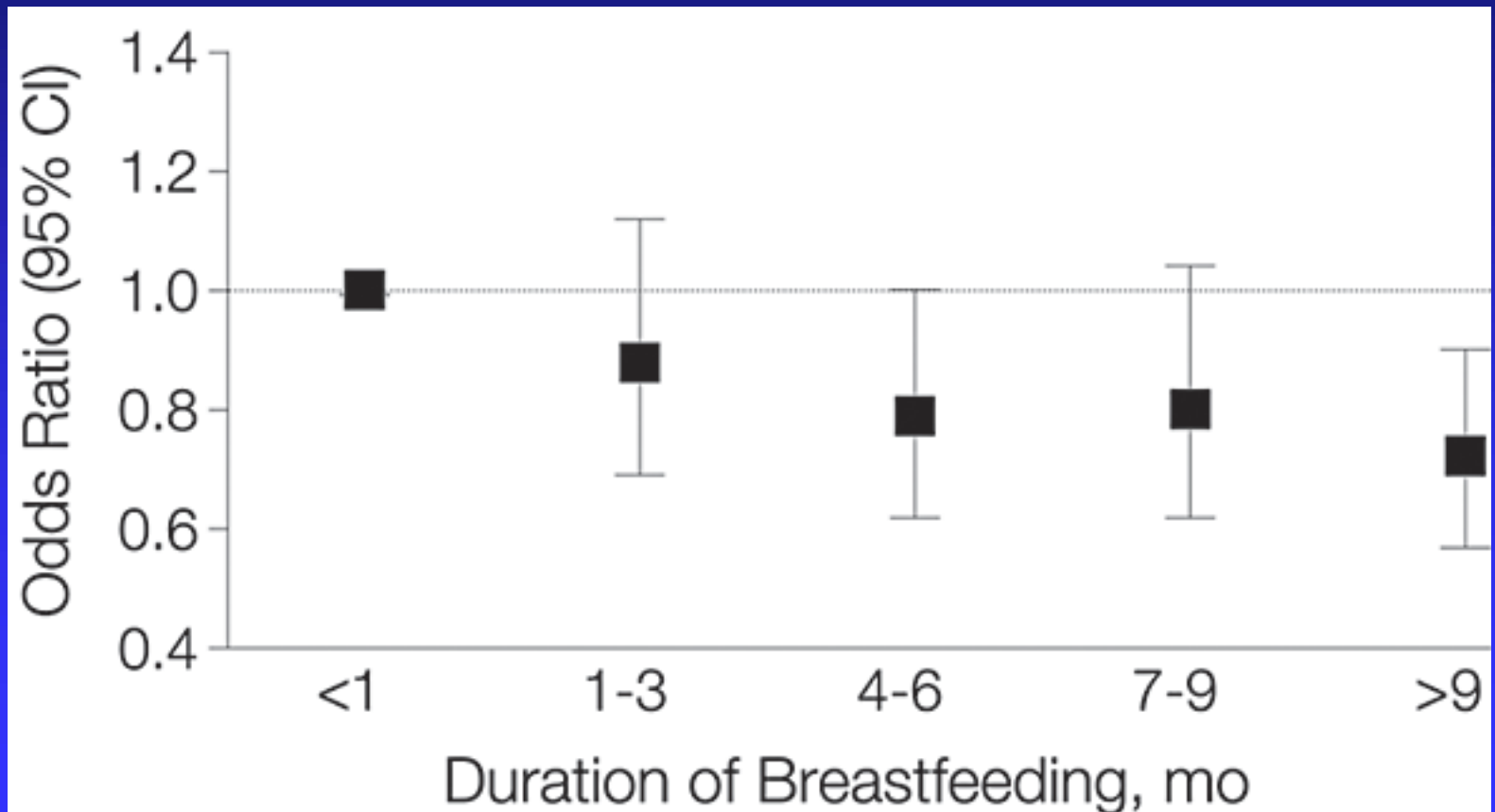
Victora

Liese et al. (Germany)

% overweight at 9-10 y of age, by duration of exclusive breastfeeding



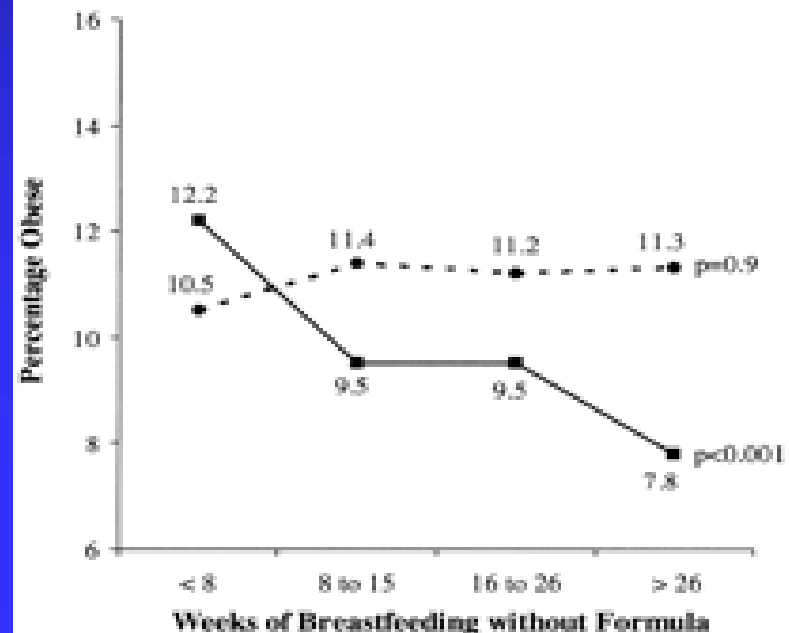
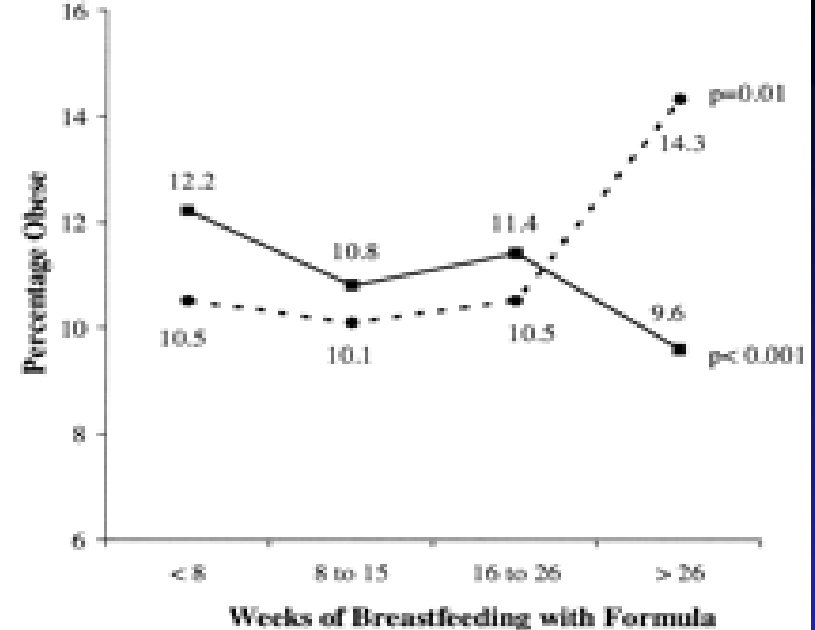
Gillman et al. (USA): Adjusted odds ratios for overweight in adolescence by duration of breastfeeding in infancy ($p = 0.007$)



Bogen et al.

Obesity Research
2004;12:1527-1535

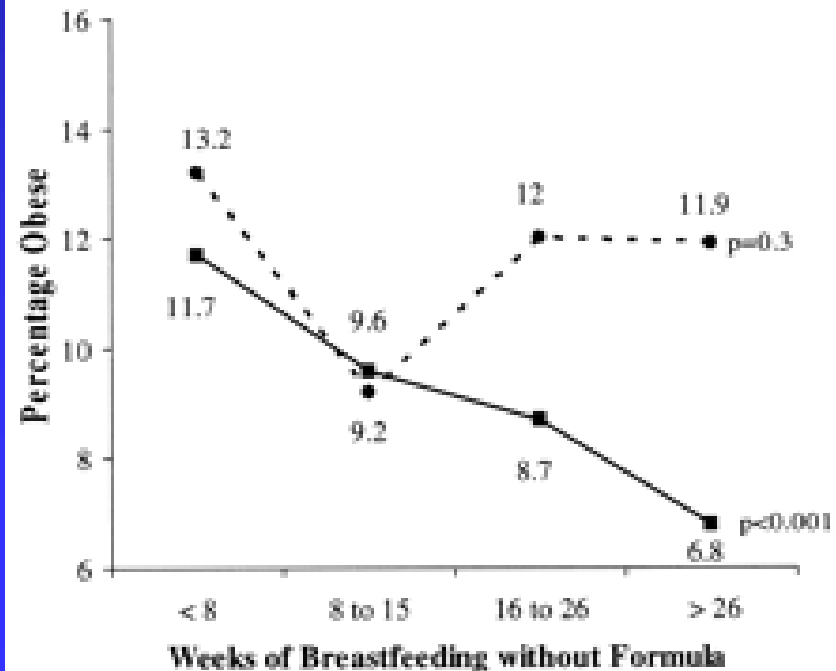
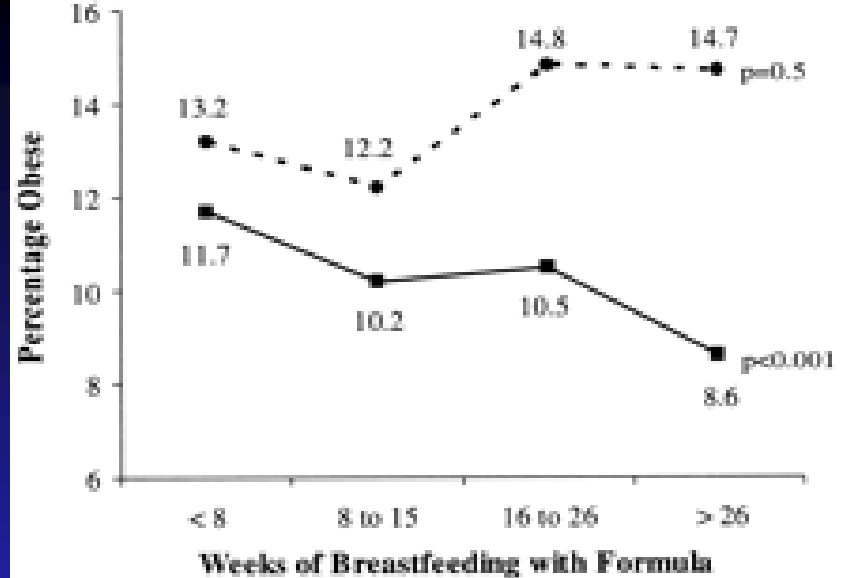
Relationship
between obesity at
age 4 y and duration
of breastfeeding and
concurrent formula
use for whites (solid
line) and blacks
(dashed line)



Bogen et al.

Obesity Research
2004;12:1527-1535

Relationship in whites
between obesity at age
4 y and duration of
breastfeeding and
concurrent formula use
for those whose
mothers did not (solid
line) and did (dashed
line) smoke during
pregnancy



Breastfeeding duration and obesity at 4 y among white children whose mothers did not smoke during pregnancy [Bogen et al., 2004]

<u>BF duration</u>	<u>AOR</u>
Never	1.00
< 8 wk	0.97
8-15 wk w/ FF	0.84
8-15 wk w/o FF	0.80
16-26 wk w/ FF	0.86
16-26 wk w/o FF	0.71*
> 26 wk w/ FF	0.70*
> 26 wk w/o FF	0.55*

* $p < 0.05$, adjusted for maternal age, education, parity, marital status, pregnancy conditions, delivery method, child sex, birth weight, birth order, birth year. Inclusion of maternal BMI did not alter the results.

Breastfeeding and subsequent obesity: potential explanations

- Learned self-regulation of energy intake
- Metabolic programming
 - ◆ Insulin
 - ◆ Leptin
 - ◆ Consequences of high protein intake in early life
- Residual confounding by attributes of mothers and/or family environment

Learned self-regulation of energy intake

- Breastfeeding allows infant to control intake based on internal satiety cues
- Bottle-fed infants may be encouraged to finish bottle even if they are full
- This may lead to later differences in ability to self-regulate energy intake

Infant self-regulation of breast milk intake

K.G. Dewey & B. Lonnerdal

Acta Paediatr Scand 1986; 75: 893-8

- 18 exclusively breastfeeding mothers stimulated milk supply by daily expression of extra milk for 2 wk. All but 4 increased milk volume by > 73 g/d.
- Among the 14 infants with access to increased milk volume, most increased intake in the first 2 d, but returned to near baseline levels of intake after 1-2 wk
- Intake increased more in fatter than leaner infants
- Breastfed infants self-regulate milk intake

Effects of over-feeding in early life?

- Animal studies

Overfeeding in infancy \Rightarrow

\uparrow adipocyte number and fat content

- Human studies

Rapid weight gain during infancy is correlated with childhood obesity

(Ong et al., 2000; Stettler et al., 2002; Cameron et al., 2003)

Stettler et al. (U.S.)

Pediatrics 2002;109:194-199

- N=19,397 children born 1959-65
- Outcome: BMI > 95th percentile at age 7 y
- Rate of weight gain during the first 4 mo was associated with risk of child obesity, even after adjustment for weight at 1 y
- Almost 20% of obesity attributable to having a rate of weight gain 0-4 mo in the top quintile

Infant feeding, plasma insulin & weight gain

- Formula-fed infants have higher plasma insulin levels and prolonged insulin response at 6 d of age (Lucas et al., 1981)
- Higher insulin levels stimulate greater adipose tissue deposition, and have been associated with subsequent ↑ weight gain & obesity in Pima Indian children 5-9 y of age (Odeleye et al., 1997)

Infant feeding, plasma insulin & weight gain (cont.)

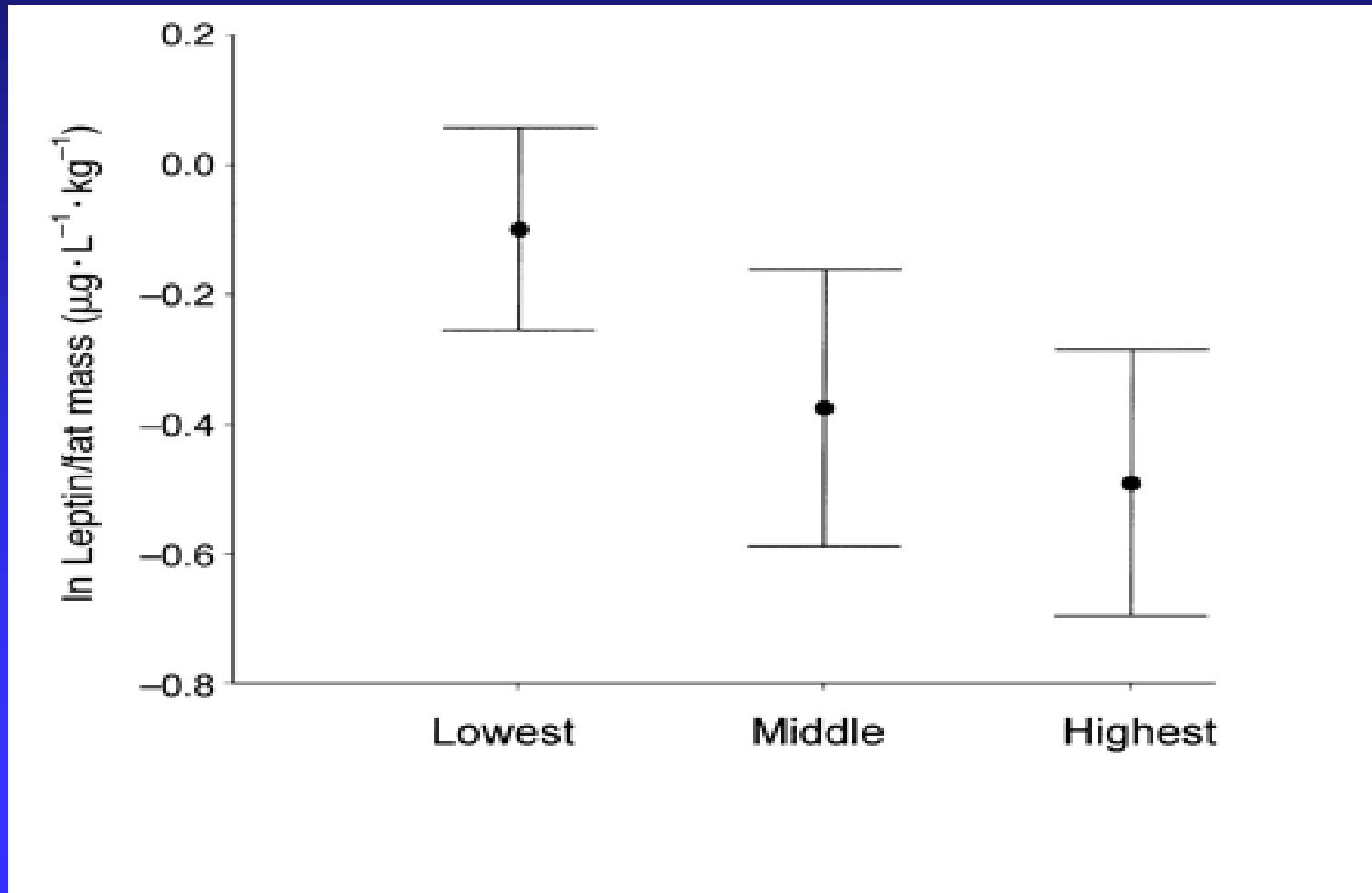
Breastfeeding is associated with:

- lower weight for height & lower rates of Type II diabetes (AOR = 0.64) in Pima Indians 10-39 y of age (Pettitt et al., 1997)
- lower risk of Type II diabetes (AOR = 0.24) in Native Canadian children [breastfed \geq 12 mo] (Young et al., 2002)
- lower risk of Type II diabetes (OR=0.75) in European children (EURODIAB Substudy 2 Study Group, 2002)
- lower fasting insulin and post-challenge glucose levels in Dutch adults 48-53 y (Ravelli et al., 2000)

Infant feeding and plasma leptin

- Plasma leptin is a key regulator of appetite and body fatness
- Breastfeeding may affect leptin levels during infancy and later in life
- Early diet of preterm infants is associated with leptin concentration at 13-16 y of age (Singhal et al., 2002)

Ratio of leptin concentration to fat mass at 13-16 y of age, by tertile of human milk intake by preterm infants in early life (median \pm 95% CI, n=191, p = 0.006; Singhal et al., 2002)



Infant feeding and plasma leptin: postulated mechanism (Singhal et al., 2002)

- Greater body fatness during infancy “programs” the leptin-dependent feedback loop to be less sensitive to leptin later in life (i.e. greater leptin resistance)
- Greater leptin resistance contributes to overeating and obesity
- In rats, overfeeding before weaning leads to overweight and leptin resistance in later life (Plagemann et al., 1999)

Early protein intake and subsequent body fatness

- Formula-fed infants consume 66-70% more protein than breastfed infants at 3-6 mo; by 12 mo, intakes may be 5-6 times the requirement
- High protein intake stimulates higher insulin secretion \Rightarrow adipose tissue deposition
- Association between high protein intake in early life and overweight in childhood reported by Rolland-Cachera et al. (1995) and Scaglioni et al. (2000), but not by Dorosty et al. (2000)

Residual confounding?

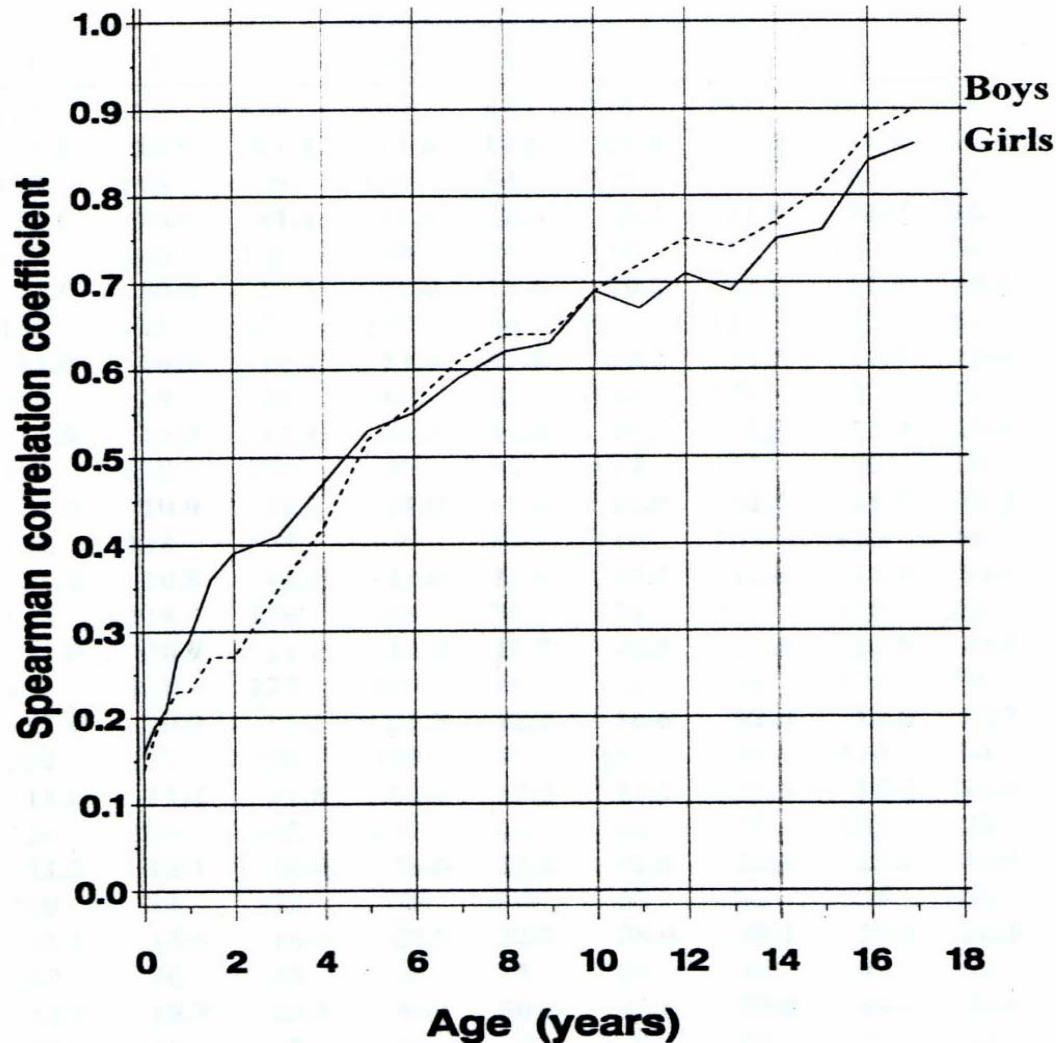
- Child feeding practices & parental control over feeding
 - ◆ Mothers who breastfed for ≥ 12 mo reported lower levels of control over feeding at 18 mo (Fisher et al., 2000)
 - ◆ Highly controlling feeding practices may interfere with child's ability to self-regulate energy intake (Birch et al., 2003)
- Physical activity
 - ◆ Breastfeeding associated with healthier lifestyle, greater physical activity?

Tracking of overweight from childhood to adulthood

Does child obesity matter?

He & Karlberg, 1999 (Sweden)

Correlation between BMI at 18 y of age and BMI from birth to 17 y of age (N=3,650)



Summary

- 13 of the 16 studies showed an association between breastfeeding and a lower risk of obesity
- 9 of the 9 studies that included comparisons between EFF and EBF, Full BF or Predominant BF for 2-6 mo showed a significant association
- 8 of the 11 studies that controlled for maternal BMI showed a significant association
- 7 of the 12 studies that categorized duration of BF showed a dose-response relationship with risk of child obesity. Lowest risk was for > 6 mo of BF.

Explanations?

- Not solely due to lower fatness during first 2 y
- Potential mechanisms include:
 - ◆ Learned self-regulation of energy intake
 - ◆ Metabolic programming due to differences in milk composition, protein intake, fatness and/or rate of weight gain in early life
 - ◆ Residual confounding, e.g. by child feeding practices, physical activity

Clinical & public health implications

- Provides further evidence to promote breastfeeding
- However, role of breastfeeding is probably small compared to other factors such as parental overweight, dietary practices and physical activity