Weight gain and linear growth in early life: impact on human capital and adult health

Cesar Victora
Federal University of Pelotas, Brazil
Underweight children, 2004
Birth cohort publications

WWW.GOPUBMED.COM (SEP 2009)
WWW.WORLDMAPPER.ORG
When does under-nutrition occur, and what are its short-term consequences?
In LMICs, growth falters in the first 2 years

Timing of growth faltering, 54 DHS surveys

Victora et al, Pediatrics (2010)
In LMICs, early under-nutrition increases short-term mortality

Low weight-for-age and subsequent mortality


Pelletier et al, J Nutr 1994
1. Under-nutrition occurs in the first 2 years and increases short-term mortality
What are the long-term consequences of under-nutrition for human capital?
The COHORTS group

Supported by
The Wellcome Trust
Lancet Series on Maternal and Child Undernutrition

Consequences for Adult Health and Human Capital

CG Victora, L Adair, C Fall, PC Hallal, R Martorell, L Richter, HS Sachdev and Maternal and Child Undernutrition Study Group

(Jan 2008)
COHORTS I (2006-7) Methods

- **Main exposures**
  - Low birthweight
  - Stunting at age 2 years

- **Main outcomes**
  - Human capital
  - Precursors/risk factors for NCDs
Adult height according to length/age at 2 yr

1 Z-score at age 2 y = 3.2 cm taller adults

Victora et al, Lancet 2008

Adjusted for several confounding variables
Achieved schooling according to length/age at 2 yr

1 Z-score at age 2 y = half a year more schooling

Adjusted for several confounding variables

Victora et al, Lancet 2008
Next generation BW according to length/age at 2 yr

Adjusted for several confounding variables

1 Z-score at age 2 y = 80 g heavier children

Victora et al, Lancet 2008
Messages

1. Under-nutrition occurs in the first 2 years and increases short-term mortality

2. Good nutrition in early life improves human capital
   - Adult height
   - Achieved schooling
   - Offspring birthweight
   - Income/wealth
But what about the effects of rapid weight gain on adult chronic diseases?

Does age matter?
Being big or growing fast: systematic review of size and growth in infancy and later obesity
Janis Baird, David Fisher, Patricia Lucas, Jos Kleijnen, Helen Roberts and Catherine Law

BMJ 2005;331;929-; originally published online 14 Oct 2005;
doi:10.1136/bmj.38586.411273.E0

Catch-up growth in childhood and death from coronary heart disease: longitudinal study
J G Eriksson, T Forsén, J Tuomilehto, P D Winter, C Osmond and D J P Barker

BMJ 1999;318;427-431

Are infant size and growth related to burden of disease in adulthood? A systematic review of literature
David Fisher,¹ Janis Baird,¹ Liz Payne,² Patricia Lucas,³ Jos Kleijnen,⁵,⁷ Helen Roberts⁴ and Catherine Law⁶,⁸

AND MANY OTHER PUBLICATIONS
Commentary: The catch-up dilemma—relevance of Leitch's 'low–high' pig to child growth in developing countries

Cesar G Victora and Fernando C Barros

Isabella Leitch's paper is exciting reading in many ways. Our main difficulty in writing this commentary was choosing a single topic from her several original ideas that have major relevance to the nutritional problems of developing countries today. We opted to discuss the possible hazards of catch-up growth.

Leitch's analogy of the growth of pigs and humans is thought-provoking. Based on research on pigs who were starved early in life and then fed appropriately, she observed that 'skeleton and muscle will not grow as they would have done if they had had the opportunity at the right time, and the extra food will be used mainly to lay on fat'. She then uses this analogy of the 'low–high' pig to propose that humans who suffered malnutrition in early life would be better off by remaining thin than

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Use of conditional weights (relative acceleration / deceleration) in 4 ages ranges:

- Birthweight
- 0-1 year
- 1-2 years
- 2 years – mid-childhood
- Mid-childhood – adulthood
Conditional variables represent *children’s deviation from expected size based on their own prior measures and on the growth of the other children in each cohort*.

These variables can be interpreted as representing *faster or slower growth*.
Size at birth, weight gain in infancy and childhood, and adult blood pressure weight

**Weight Gain in the First Two Years of Life Is an Important Predictor of Schooling Outcomes in Pooled Analyses from Five Birth Cohorts from Low**
Original Research Article

Reynalda Carolin
Cesar C

Growth Patterns in Early Childhood and Final Attained Stature: Data from Five

**Size at Birth, Weight Gain in Infancy and Childhood, and Adult Diabetes Risk in Five Low- or Middle-Income Country Birth Cohorts**

Christopher W. Kuz
Nanette Lee,
Shani
ARYEH D. STEIN,
and

Shane A. Norris, PhD
Clive Osmond, PhD
Denise Gigante, PhD
Christopher W. Kuzawa, PhD
Laacksy Ramakrishnan, PhD
Nanette R. Lee, PhD

Manuel Ramirez-Zea, PhD
Linda M. Richter, PhD
ARYEH D. STEIN, PhD
Micheal Tandon, MD
Caroline H.D. Fall, DM
THE COHORTS GROUP

with an increased incidence of DM and insulin resistance (2). Therefore, impaired fetal growth and excess postnatal weight gain are both potential precursors to adult DM. Four-fifths of all individuals with DM live in low- and middle-income countries.
COHORTS hypothesis

Human capital and short-term mortality

Risk of chronic diseases

Effect size

Birth  1 y  2 y  4 y  Adult

Conditional weight
COHORTS results

- Schooling
- Human capital and short-term mortality
- Height
- Risk of chronic diseases

Effect size

Birth 1 y 2 y 4 y Adult

Conditional weight

Glucose

COHORTS Consortium of Health Orientated Research in Transitioning Societies
Brazil Guatemala India Philippines South Africa
Blood pressure increases with weight gain at all ages, but particularly after mid-childhood.

Risk of chronic diseases.
Fat and lean mass

- BW and weight trajectories up to 24 months are more strongly associated with adult fat-free mass than with fat mass.

- Weight trajectories in mid-childhood predict both fat mass and fat-free mass.
1. Under-nutrition occurs in the first 2 years and increases short-term mortality
2. Weight gain in the first 2 years improves human capital
3. The timing of weight gain affects the future risk of chronic diseases
   1. Early weight gain is neutral or even protective
   2. Later weight gain is consistently detrimental
Can we separate weight gain from linear growth?
Methods

- Conditional weights
  - Conditional on earlier weight and height gains

- Conditional heights
  - Conditional on earlier height and weight gains

- Four age ranges
  - Birthweight
  - 0-2 years
  - 2 years – mid-childhood
  - Mid-childhood – adulthood
Disentangling how relative weight gain versus linear growth during early life relate to adult health and human capital in cohorts from five low and middle income countries

Linda Adair, Caroline Fall, Clive Osmond and the COHORTS group (forthcoming)
Odds* of adverse outcomes associated with birth weight and CW through mid-childhood

*OR and 95% CI
Odds* of adverse outcomes associated with faster linear growth through mid-childhood

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*OR and 95% CI
1. Under-nutrition occurs in the first 2 years and increases short-term mortality
2. Weight gain in the first 2 years improves human capital
3. The timing of weight gain affects the future risk of chronic diseases
4. Linear growth has few if any of the detrimental effects of weight gain
Challenges

1. How do we translate these findings to policy makers?
2. How do we measure linear growth in low-income settings?
3. How do can we promote linear growth without making children fatter?
How early to prevent obesity in LMICs?

PREVENT LOW BIRTHWEIGHT

PREVENT GROWTH FALTERING

GREATER EMPHASIS ON LINEAR GROWTH

PREVENT RAPID WEIGHT GAIN

Victora et al, Pediatrics (2010)