European Journal of Clinical Nutrition (2009) 63, 369–374

0954-3007/09 $32.00
www.nature.com/ejcn

ORIGINAL ARTICLE

Weight catch-up and achieved schooling at 18 years of age in Brazilian males

BL Horta[1], DW Sibbritt[2], RC Lima[3] and CG Victora[1]

[1]*Post-Graduate Programme in Epidemiology, Universidade Federal de Pelotas, Pelotas, Brazil;* [2]*Centre for Clinical Epidemiology and Biostatistics, University of Newcastle, Australia and* [3]*School of Medicine and Psychology, Universidade Catσlica de Pelotas, Pelotas, Brazil*

Objective: To assess the relationship between weight catch-up in infancy and achieved schooling at 18 years of age in Brazilian males.
Subjects: All newborn infants in the city's hospitals were enrolled in 1982; 78.8% (2250) of all male participants were located at age 18 years when enrolling in the national army.
Results: According to the Brazilian school calendar, 18-year-olds should be attending the 11th grade, but school failure was very common and 78.5% of all subjects had failed at least once. The average achieved schooling was 7.7 years (s.d. = 2.3). After controlling for possible confounding variables, birthweight was positively associated with achieved schooling. With respect to postnatal growth, weight gain in the first 20 months was associated with increased schooling. Among SGA infants who caught-up in weight, achieved schooling was 1.3 higher. Data from a cross-sectional survey in the same population suggest that such a difference corresponds to a 25% difference in adult income levels.
Conclusion: The study showed that early weight catch-up is associated with achieved schooling. The beneficial effects of early weight gain should be balanced against its potential harms.
European Journal of Clinical Nutrition (2009) **63,** 369–374; doi:10.1038/sj.ejcn.1602934; published online 24 October 2007

Keywords: postnatal growth; catch-up; schooling; birthweight

Introduction

In low and middle-income countries, rapid growth in early childhood has short-term benefits. Small for gestational age (SGA) infants with accelerated growth in the first 20 months of life have lower mortality and fewer hospital admissions subsequently.(Victora *et al*., 2001) On the other hand, several studies suggest that rapid growth might increase the risk of coronary heart disease, hypertension and insulin resistance (Eriksson and Forsen, 2002). In view of the conflicting evidence, more studies are needed to assess the pros and cons of rapid growth in infancy, to help quantify the so-called catch-up dilemma (Victora and Barros, 2001).

Several studies from developing countries have reported an association between malnutrition in infancy and motor development, deficits in cognition or school performance in later childhood or adolescence (Sigman *et al*., 1991; Mendez and Adair, 1999; Ivanovic *et al*., 2000; Walker *et al*., 2000; Cheung *et al*., 2001; Berkman *et al*., 2002; Daniels and Adair, 2004). However, there is scarce evidence on the effect of rapid growth. Richards *et al*. (2002) reported that height gain in early childhood and late adolescence was positively associated with cognitive function at age 26. Li *et al*. (2004) observed that growth in length and head circumference from birth to 2 years of age—but not birth size or late postnatal growth—was associated with women's educational achievement. Height gain from birth to 9 years was also positively associated with intelligence quotient score at age 11 years (Pearce *et al*., 2005). Lundgren *et al*. (2001) observed that SGA subjects who attained normal height at conscription presented a better intellectual and psychological performance

Correspondence: Dr BL Horta, Rua Triunfo 3080, 96090-790 Pelotas, Brazil.
E-mail: blhorta@uol.com.br
Guarantor: BH Horta.
Contributors: BLH carried out data analyses and writing of the manuscript. DWS advised on data analyses, and provided critical inputs to the writing up of the manuscript. RCL coordinated the fieldwork for the current phase of the study and constructed the database. CGV have coordinated the cohort study from its inception, supervising data collection and analyses and contributed to the writing of the paper. BLH is the guarantor for the paper.
Received 3 July 2006; revised 12 September 2007; accepted 13 September 2007; published online 24 October 2007

than those SGA subjects who failed to reach normal adult height. Geva *et al*. (2006) noticed that catch-up growth had a positive impact on visuomotor functioning of SGA subjects. Silva *et al*. (2006) also observed that head and somatic (height and weight) postnatal growth were independently associated with cognition at age 10. Among Filipino children, increase in height-for-age *z*-score from birth to 2 years was inversely related with the risk of school failure (Daniels and Adair, 2004).

Given the need for more evidence concerning the effect of catch-up on schooling, we assessed the effect of weight gain in infancy and adolescence on achieved schooling in a cohort of adolescents males aged 18 years, who are being followed up since birth in Pelotas, southern Brazil.

Methods

The study was carried out in Pelotas, a relatively developed city in southern Brazil (current population 320 000), located near the border with Uruguay and Argentina. The population is mostly white, of Portuguese and Spanish background. The infant mortality rate at the time of the study was 38 per thousand live births.

In 1982, the three maternity hospitals in the city were visited daily and all 5914 live births were included in the study. These infants were examined and their mothers interviewed. Birthweight was assessed with calibrated pediatric scales. Gestational age was calculated according to the recalled date of the mother's last menstrual period. Children whose birthweight was below the 10th centile for gestational age and sex, according to the reference developed by Williams *et al*. (1982) were classified as SGA.

In 1984 (mean age 20 months), a city-wide census was conducted to locate children born in 1982, and 87% of the cohort was located. Children were weighed using a portable spring scale with an accuracy of ± 100 g. A similar census was repeated in 1986 (mean age 42 months), when 84% of all cohort children were located.

In 2000, all males in the birth cohort who were still living in Pelotas were required to undergo a medical examination at the local Army Base, and were then invited to participate in a separate examination for research purposes. They were then invited to answer a research questionnaire that included information on schooling. The outcome variable was the highest school grade successfully completed by the subject. This was treated as a continuous variable in the analyses.

Those who were agreeable underwent the interview and physical examination. Male adolescents who did not attend the Army examination were sought at their last known address and invited to attend an examination at a clinic. Those who still failed to attend were visited at home.

Birthweight *z*-scores were computed using the Williams's reference (Williams *et al*., 1982). In the follow-up visits, *z*-scores were calculated using age and sex-specific values from the NCHS growth reference (Hamill *et al*., 1979). Changes in *z*-score between birth and the follow-up visits were calculated; these are hence referred to as 'weight gain'.

Confounding variables collected in the early phases of the study included monthly family income, maternal and paternal education, household assets index (obtained through factor analysis and based on the ownership of household goods), (Filmer and Pritchett, 2001) social class (based on an occupational classification of the head of the household), birthweight (g), maternal smoking in pregnancy (non-smokers, 0–14 or 15 or more cigarettes per day) and number of siblings (in 1986). Information on ethnicity/skin color was based on self-classification during the 2000 interview (white, mixed, black, Asian, native Brazilian).

Means were compared using analysis of variance. General linear models were used to adjust for possible confounding variables. To obtain the coefficients for the life plot analysis, we used multiple linear regression.

The study was approved by the Ethical Review Board of the Faculty of Medicine of the Federal University of Pelotas, and written informed consent was obtained from participating subjects.

Results

A total of 2250 subjects were interviewed at the age of 18 years. Added to the 143 cohort males known to have died, they represented 78.8% of all live born boys. As reported elsewhere, (Victora *et al*., 2003) losses to follow-up were more frequent among the poorest (27%) and the richest (23%), compared to 16% in the middle income group. There were no clear trends in follow up rates relative to maternal education, maternal ethnicity, birthweight or breastfeeding duration.

The prevalence of low birthweight, preterm delivery and intrauterine growth retardation were 5.9, 5.2 and 15.0%, respectively. Mean weight for age *z*-scores were -0.23 and -0.05 at mean age of 20 and 42 months, respectively. (Table 1).

According to the Brazilian school calendar, 18-year-old boys should have achieved at least 11 years of schooling. However, school failure was very common and 78.5% of all subjects had failed at least once. The average achieved schooling was 7.7 (s.d. = 2.3), and about one quarter (25.7%) of subjects were no longer attending school.

Table 2 shows that achieved schooling was lower among low birthweight infants. Even after controlling for possible confounding variables, achieved schooling was positively associated with birthweight (*P*-value for linear trend = 0.01), and schooling among low birthweight subjects was 0.5 grades lower than that observed among those whose birthweight was $\geqslant$4000 g. Similarly, birthweight for gestational age *z*-score was also positively associated with achieved schooling. Those infants whose birthweight was $\geqslant$2.33 standard deviations below the mean according to gestational

Table 1 Distribution of sample according to key characteristics

Sample characteristics	*N*	
At birth		
Birthweight (g)[a]	2250	3294.0 (521.5)
Low birthweight (%)	2250	5.9%
Preterm birth (%)	1821	5.2%
Small for gestational age (%)	1822	15.0%
1984 follow-up visit		
Weight for age *z*-scores		
<−2	102	4.9
−2 to −1.01	412	19.9
−1 to 0.99	1260	61.0
⩾1	293	14.2
Mean and standard deviation	2067	−0.23 (1.15)
1986 follow-up visit		
Weight for age *z*-scores		
<−2	50	2.5
−2 to −1.01	321	15.8
−1 to 0.99	1354	66.7
⩾1	306	15.1
Mean and standard deviation	2031	−0.05 (1.15)

[a]Mean (standard deviation).

Table 2 Mean and 95% confidence limits for highest grade completed at school by 18-year-old males, according to birthweight, gestational age and intrauterine growth retardation

	Schooling in years (95% confidence interval)		*N*
	Crude[a]	*Adjusted*[b]	
Birthweight (grams)	*P*<0.001‡	*P*=0.01‡	
<2500	7.0 (6.6–7.4)	7.5 (7.1–7.8)	128
2500–2999	7.5 (7.3–7.7)	7.8 (7.6–8.1)	444
3000–3499	7.7 (7.5–7.8)	7.9 (7.7–8.1)	848
3500–3999	7.9 (7.7–8.1)	8.0 (7.8–8.2)	623
⩾4000	8.0 (7.7–8.4)	8.0 (7.7–8.4)	179
Preterm delivery	*P*=0.06†	*P*=0.19†	
Yes	7.4 (6.9–7.9)	7.7 (7.3–8.1)	94
No	7.9 (7.8–8.0)	7.9 (7.8–8.1)	1708
Birthweight for gestational age *z*-score	P<0.001‡	*P*=0.02‡	
<−2.33	7.1 (6.4–7.9)	7.7 (7.0–8.5)	28
−2.33 to 1.28	7.3 (7.1–7.6)	7.9 (7.6–8.1)	240
−1.27 to 0	7.8 (7.6–7.9)	8.0 (7.8–8.2)	787
0 to 1.27	8.0 (7.9–8.2)	8.1 (7.9–8.3)	629
>1.27	8.4 (8.0–8.8)	8.2 (7.9–8.6)	118
Total			2222

[a]Analysis of variance.
[b]General linear model (factorial); estimates adjusted for household assets, family income, parental schooling at birth, maternal smoking during pregnancy and skin color.
†Test for heterogeneity.
‡Test for linear trend.

age and sex had a mean schooling of 7.7 years (95% confidence interval: 7.0–8.5), infants whose birthweight was ⩾1.28 above the mean attained in mean 8.2 years (95% confidence interval: 7.9–8.6). On the other hand, preterm birth was not associated with achieved schooling.

Table 3 Change in schooling (years) associated with a one *z*-score increase in birth weight and weight for age *z*-scores at the mean ages of 20 months (1984) and 42 months (1986)

Model	*Multiple linear equation*	*Regression coefficient and 95% confidence interval for years of schooling in 2000 (age 18 years)*
1	Birthweight *z*-score 1982	0.275 (0.166–0.384)
2	Birthweight *z*-score 1982	0.022 (−0.095 to 0.139)
	Weight for age *z*-score 1984	0.548 (0.441–0.655)
3	Birthweight *z*-score 1982	0.023 (−0.093 to 0.140)
	Weight for age *z*-score 1984	0.315 (0.138–0.492)
	Weight for age *z*-score 1986	0.277 (0.110–0.445)
4[a]	Birthweight *z*-score 1982	−0.009 (−0.113 to 0.093)
	Weight for age *z*-score 1984	0.169 (0.014 to 0.324)
	Weight for age *z*-score 1986	0.106 (−0.041 to 0.253)

[a]Controlling for household assets, family income, parental schooling at birth, maternal smoking during pregnancy, breastfeeding duration and skin color.

In the multivariate analysis, anthropometric variables were included in a stepwise fashion, according to when they were measured. Table 3 shows that an increment of one *z*-score in birthweight increased achieved schooling in 0.275 years (95% confidence interval: 0.166–0.384). When weight at 20 months was added to the model, the effect of birthweight was reduced and became no longer significant, whereas weight at 20 months presented a direct association with schooling. The effect of weight at 20 months decreased after inclusion of weight at 42 months, but was still statistically significant. However, after controlling for possible confounding variables (model 4), only weight at 20 months continued to show a positive association with achieved schooling.

Figure 1 presents the regression coefficients of achieved schooling on weight at the three different ages (model 4 from Table 3), confirming that fast weight gain in the first 2 years of life is positively associated with schooling. The slightly negative coefficient at birth (−0.009) compared with the positive coefficient at 20 months (0.169) shows that early weight gain has a positive effect on achieved schooling. Because the coefficient at 42 months was similar to that at 20 months, weight gain between 20 and 42 months had no effect on schooling.

The effect of early weight gain on achieved schooling was estimated in a multiple linear regression model that included change in *z*-score from birth to 20 months, birthweight *z*-score and the confounding variables. By increasing one *z*-score from birth to mean age 20 months, achieved schooling increased by 0.258 (0.166–0.350; $P=<0.001$) years. Similar analyses showed that one *z*-score of weight gain from 20 to 42 months, after adjustment, was associated with a change of 0.075 (−0.056 to 0.206; $P=0.26$), confirming that weight gain from 20 to 42 months was not associated with achieved schooling.

Figure 2 shows the effect of weigh gain from birth to 20 months, stratified by tertiles of birthweight for gestational

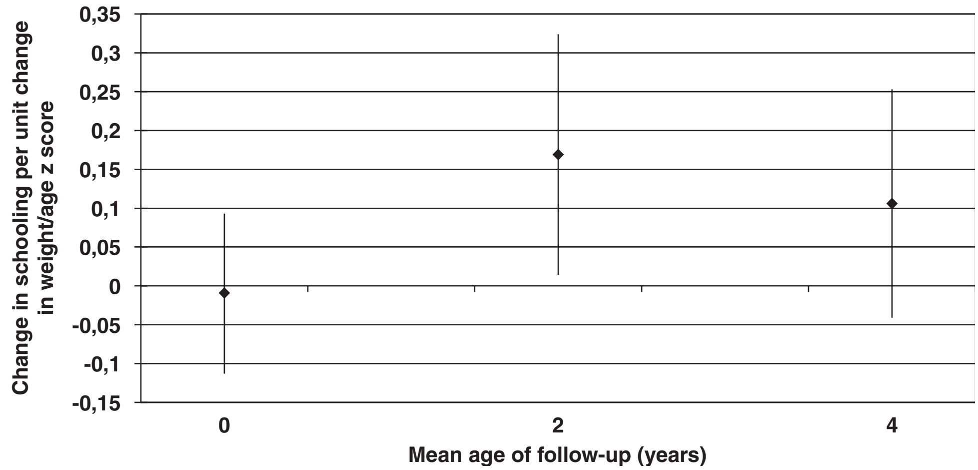

Figure 1 Change in schooling (years) associated with a one *z*-score increase in birth weight and weight for age *z*-scores at the mean ages of 20 months (1984) and 42 months (1986). Adjusted for family income, breastfeeding duration, parental schooling at birth, household assets, maternal smoking during pregnancy and skin color.

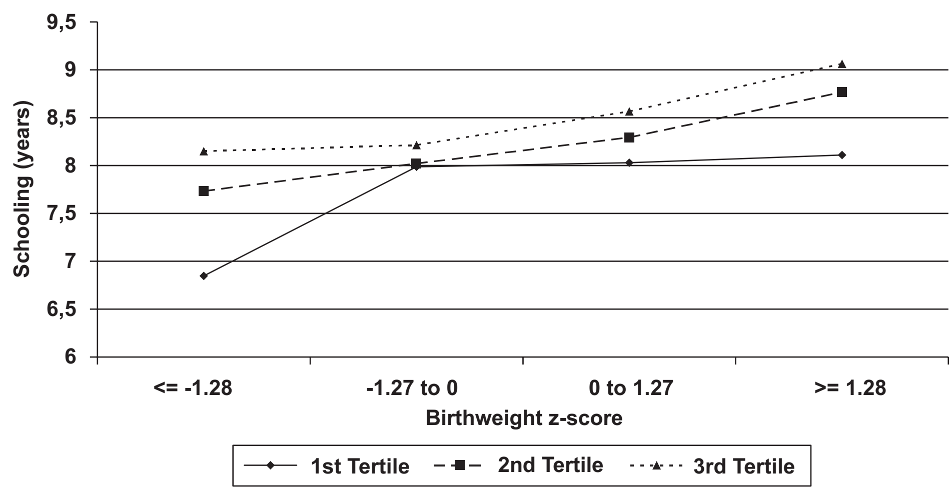

Figure 2 Achieved schooling according to birthweight *z*-score by tertiles of weight gain from birth to 20 months of age. Adjusted for family income, breastfeeding duration, parental schooling at birth, household assets, maternal smoking during pregnancy and skin color.

age. Children whose change in *z*-score was in the third tertile were considered as presenting rapid weight gain, and those in the first tertile were classified as presenting slow weight gain. The highest mean schooling was observed among those infants whose birthweight was at or above the 90th centile (1.28 or more standard deviations above the mean) and presented rapid weigh gain from birth to 20 months (9.1 years (95% confidence interval: 7.9–10.2)). On the other extreme, SGA infants (birthweight *z*-score $\leqslant -1.28$ s.d. or 10th centile) who presented slow weight gain from birth to 20 months had the lowest achieved schooling (6.8 years (95% confidence interval: 5.9–7.8)). Mean achieved schooling among SGA infants who presented rapid weight gain (catch-up) was 8.2 years (95% confidence interval: 7.8–8.5), being equal to that of children who were large at birth but presented slow weight gain (catch-down).

Among children who presented average or rapid weight gain, achieved schooling increased linearly with birthweight for gestational age and this association was not modified by socioeconomic status in childhood. There is a suggestion, that a linear association may not be present for infants who showed slow weight gain in early childhood (Figure 2), but a test for interaction between birthweight for gestational age and growth velocity was not significant ($P = 0.33$).

Discussion

At 18 years of age, among male subjects, birthweight for gestational age *z*-score was positively associated with school achievement, but a stronger effect was found for early weight gain, from birth to 20 months. On the other hand, weight gain from 20 to 42 months did not have an effect.

The association between fetal growth and achieved schooling or cognitive ability has been reported in previous studies (Cheung *et al*., 2001; Shenkin *et al*., 2004; Corbett *et al*., 2007) and persisted even after adjusting for socioeconomic variables. Our findings of a stronger effect of early weight gain are biologically plausible. Growth velocity of the human brain is higher in the postnatal period than in intrauterine period, and the growth is particularly rapid in the first 6 months of life (Dobbing and Sands, 1979). Indeed, Gale *et al*. (2004) reported that brain growth during early childhood was more important than intrauterine growth in determining cognitive function at 9 years of age. On the other hand, Richards *et al*. (2002) assessed the effect of growth at different ages and observed that height gain from 2 to 4 years was associated with cognition at age 8, whereas height gain from birth to 2 years did not present such an association.

The effect of weight gain in childhood on achieved schooling was not due to an association between early growth and behavior (smoking, alcohol intake) and morbidity at adolescence because the effect of early weight gain was not modified by the control for these variables; the regression coefficients for birthweight and weight for age *z*-score in 1984 changed from −0.009 (95% confidence interval: −0.113 to 0.093) and 0.169 (confidence interval: 0.014–0.324) to 0.002 (confidence interval: −0.100 to 0.103) and 0.208 (confidence interval: 0.056–0.360), respectively.

Among SGA infants, early weight gain was able to help these infants to partially overcome the negative effect of intrauterine growth restriction, and achieved schooling was similar to those infants whose birthweight *z*-score was between −1.27 and +1.27 s.d. Furthermore, among SGA infants, weight gain in early childhood was associated with an increase of 1.3 grades, as compared to SGA infants who presented slow weight gain. Based on data from a previous study (Hallal *et al*., 2003), we estimated the effect of increasing number of years of schooling on income; each additional grade of achieved schooling was associated with an increase of R$131. Among SGA infants, the difference in income associated with catch-up growth would be R$170, or about 25% of the average income level of R$691.

Some limitations may have affected our results. It was not possible to locate approximately 21% of the target population. However, the proportions of children with rapid weight gain were similar among those who were located at age 18 years and those who were lost to follow-up (27.4 and 25.8%, respectively). It is therefore unlikely that the above results have been affected by selection bias. Other studies have assessed the effect of linear growth on intellectual performance (Lundgren *et al*., 2001; Pearce *et al*, 2005). Unfortunately, we were not able to assess the effect of linear growth, as information on birth length was not gathered during the perinatal study.

In order to prevent confounding by socioeconomic status, we included several socioeconomic variables, reflecting different aspects of the social and home environment. These variables were prospectively measured in early childhood, thus avoiding recall bias and misclassification. Correlation coefficients between socioeconomic variables and weight for age at 2 and 4 years were similar. Therefore, the greater effect of early weight gain, relative to later weight gain on schooling levels cannot be due to residual confounding by socioeconomic factors.

The positive effect of weight gain on achieved schooling could be due to paternal attention and care, since parental care is associated with growth and mental development in childhood (Krugman and Dubowitz, 2003). As, we have not measured the attention or stimulation that the subjects received in childhood, we were not able to control for this variable.

Previous analyses of our cohort data show that weight catch-up in early infancy has short-term benefits on morbidity and mortality, (Victora *et al*., 2001) but on the other hand is associated with higher blood pressure (Horta *et al*., 2003) and overweight (Monteiro *et al*., 2003) in adolescence, a finding confirmed by other studies (Monteiro and Victora, 2005). We now provide evidence of another beneficial effect of early weight catch-up, this time on school achievement. There is a clear need for more research to quantify the advantages and disadvantages of rapid growth in infancy to help solve the 'the catch up dilemma' (Victora and Barros, 2001).

Acknowledgements

This analysis was supported by the Wellcome Trusts initiative entitled Major Awards for Latin America on Health Consequences of Population Change. Earlier phases of the 1982 cohort study were funded by the International Development Research Center (Canada), the World Health Organization (Department of Child and Adolescent Health and Development, and Human Reproduction Programme), the Overseas Development Administration (United Kingdom), the United Nations Development Fund for Women, the National Program for Centers of Excellence (Brazil), the National Research Council (Brazil) and the Ministry of Health (Brazil).

References

Berkman DS, Lescano AG, Gilman RH, Lopez SL, Black MM (2002). Effects of stunting, diarrhoeal disease, and parasitic infection during infancy on cognition in late childhood: a follow-study. *Lancet* **359**, 564–571.

Cheung YB, Yip PSF, Karlberg JPE (2001). Fetal growth, early postnatal growth and motor development in Pakistani infants. *Int J Epidemiol* **30**, 66–74.

Corbett SS, Drewett RF, Durham M, Tymms P, Wright CM (2007). The relationship between birthweight, weight gain in infancy, and educational attainment in childhood. *Paediatr Perinat Epidemiol* **21**, 57–64.

Daniels MC, Adair LS (2004). Growth in young Filipino children predicts schooling trajectories through High School. *J Nutr* **134**, 1439–1446.
Dobbing J, Sands J (1979). Comparative aspects of the brain growth spurt. *Early Human Dev* **3**, 79–83.
Eriksson JG, Forsen TJ (2002). Childhood growth and coronary heart disease in later life. *Ann Med* **34**, 157–161.
Filmer D, Pritchett LH (2001). Estimating wealth effects without expenditure data or tears: an application to educational enrollments in states of India. *Demography* **38**, 115–132.
Gale CR, O'Callaghan FJ, Godfrey KM, Law CM, Martyn CN (2004). Critical periods of brain growth and cognitive function in children. *Brain* **127**, 321–329.
Geva R, Eshel R, Leitner Y, Valevski AF, Harel S (2006). Neuropsychological outcome of children with intrauterine growth restriction: a 9-year prospective study. *Pediatrics* **118**, 91–100.
Hallal PC, Victora CG, Wells JCK, Lima RC (2003). Pysical inactivity: prevalence and associated variables in a Brazilian adult population. *Med Sci Sports Exerc* **35**, 1894–1900.
Hamill PV, Drizid TA, Johnson CL, Reed RB, Roche AF, Moore WM (1979). Physical growth: National Center for Health Statistics percentiles. *Am J Clin Nutr* **32**, 607–629.
Horta BL, Barros FC, Victora CG, Cole TJ (2003). Early and late growth and blood pressure in adolescence. *J Epidemiol Community Health* **57**, 226–230.
Ivanovic DM, Leiva BP, Perez HT, Inzunza NB, Almagia AF, Toro TD *et al*. (2000). Long-term effects of severe undernutrition during the first year of life on brain development and learning in Chilean high-school graduates. *Nutrition* **11–12**, 1056–1063.
Krugman SD, Dubowitz H (2003). Failure to thrive. *Am Fam Physician* **68**, 879–884.
Li HJ, DiGirolamo AM, Barnhart HX, Stein AD, Martorell R (2004). Relative importance of birth size and postnatal growth for women's educational achievement. *Early Hum Dev* **76**, 1–16.
Lundgren EM, Cnattingius S, Jonsson B, Tuvemo T (2001). Intellectual and psychological performance in males born small for gestational age with and without catch-up growth. *Pediatr Res* **50**, 91–96.
Mendez MA, Adair LS (1999). Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood. *J Nutr* **129**, 1555–1562.
Monteiro PO, Victora CG (2005). Rapid growth in infancy and childhood and obesity in later life—a systematic review. *Obes Rev* **6**, 143–154.
Monteiro PO, Victora CG, Barros FC, Monteiro LM (2003). Birth size, early childhood growth, and adolescent obesity in a Brazilian birth cohort. *Int J Obes Relat Metab Disord* **27**, 1274–1282.
Pearce MS, Deary IJ, Young AH, Parker L (2005). Growth in early life and childhood IQ at age 11 years: the Newcastle Thousand Families Study. *Int J Epidemiol* **34**, 673–677.
Richards M, Hardy R, Kuh D, Wadsworth MEJ (2002). Birthweight, postnatal growth and cognitive function in a national UK birth cohort. *Int J Epidemiol* **31**, 342–348.
Shenkin SD, Starr JM, Deary IJ (2004). Birth weight and cognitive ability in childhood: a systematic review. *Psychol Bull* **130**, 989–1013.
Sigman M, McDonald MA, Neumann C, Bwibo N (1991). Prediction of cognitive competence in Kenyan children from toddler nutrition, family characteristics and abilities. *J Child Psychol Psychiatry* **32**, 307–320.
Silva A, Metha Z, O'Callaghan FJ (2006). The relative effect of size at birth, postnatal growth and social factors on cognitive function in late childhood. *Ann Epidemiol* **16**, 469–476.
Victora CG, Barros FC (2001). Commentary: the catch-up dilemma—relevance of Leitch's 'low-high' pig to child growth in developing countries. *Int J Epidemiol* **30**, 217–220.
Victora CG, Barros FC, Horta BL, Martorell R (2001). Short-term benefits of catch-up growth for small-for-gestational-age infants. *Int J Epidemiol* **30**, 1325–1330.
Victora CG, Barros FC, Lima RC, Horta BL, Wells JCK (2003). Anthropometry and body composition of 18-year-old males according to breastfeeding duration: a birth cohort study from Brazil. *BMJ* **327**, 901–904.
Walker SP, Grantham-McGregor SM, Powell CA, Chang SM (2000). Effects of growth restriction in early childhood on growth, IQ, and cognition at age 11 to 12 years and the benefits of nutritional supplementation and psychosocial stimulation. *J Pediatr* **137**, 36–41.
Williams RL, Creasy RK, Cunningham GC, Hawes WE, Norris FD, Tashiro M (1982). Fetal growth and perinatal viability in California. *Obstet Gynaecol* **59**, 624–632.