

# Early determinants of physical activity in adolescence: prospective birth cohort study

Pedro C Hallal, Jonathan C K Wells, Felipe F Reichert, Luciana Anselmi, Cesar G Victora

Postgraduate Program in Epidemiology, Federal University of Pelotas, Duque de Caxias 250 3° piso 96030-002 Pelotas-RS, Brazil

Pedro C Hallal  
*associate professor*

Felipe F Reichert  
*PhD student*

Luciana Anselmi  
*PhD student*

Cesar G Victora  
*professor*

MRC Childhood Nutrition Centre, Institute of Child Health, London  
Jonathan C K Wells  
*reader*

Postgraduate Program in Epidemiology, Federal University of Pelotas; Institute of Psychology, Federal University of Rio Grande do Sul, Brazil

Luciana Anselmi  
*PhD student*

Correspondence to:  
P C Hallal  
prchallal@terra.com.br

BMJ 2006;332:1002-5

## Abstract

**Objective** To examine the effects of early social, anthropometric, and behavioural variables on physical activity in adolescence.

**Design** Prospective birth cohort study.

**Setting** Pelotas, southern Brazil.

**Participants** 4453 adolescents aged 10-12 years participating in the Pelotas 1993 birth cohort study (follow-up rate 87.5%).

**Main outcome measures** Sedentary lifestyle (< 300 minutes of physical activity per week) and median physical activity score (minutes per week).

**Results** The prevalence of a sedentary lifestyle at age 10-12 years was 58.2% (95% confidence interval 56.7% to 59.7%). Risk factors for a sedentary lifestyle in adolescence were female sex, high family income at birth, high maternal education at birth, and low birth order. Weight gain variables at ages 0-1, 1-4, and 4-11 years and overweight at age 1 or 4 years were not significant predictors of physical activity. Levels of physical activity at age 4 years, based on maternal report, were inversely related to a sedentary lifestyle at age 10-12 years.

**Conclusions** Physical activity in adolescence does not seem to be programmed by physiological factors in infancy. A positive association between birth order and activity may be due to greater intensity of play in childhood and adolescence. Tracking of physical activity from age 4 to 10-12 years, however, suggests that genetic factors or early habit formation may be important.

## Introduction

Although most chronic diseases associated with physical inactivity typically occur in middle age and beyond, it is increasingly understood that their development starts in childhood and adolescence.<sup>1</sup> Most studies on effects of early life factors on health status have focused on physiological outcomes such as blood pressure<sup>2-3</sup> and obesity.<sup>4</sup> We examined the effect of early social, anthropometric, and behavioural variables on levels of physical activity in 10-12 year olds using a prospective study design.

## Methods

In 1993, mothers of all hospital born children in Pelotas, southern Brazil, were invited to join a birth cohort study. They were interviewed after delivery for personal, socioeconomic, and behavioural variables. Family income was divided into five groups ( $\leq 1$ , 1.1-3, 3.1-6, 6.1-10,  $> 10$  minimum wages per month). Mother's education was defined as the highest degree completed (0, 1-4, 5-8,  $\geq 9$  years). Prepregnancy weight was obtained by maternal self report, and the mothers' height was measured at the hospital. The prepregnancy body mass index was divided into four

categories (< 20, 20-24.9, 25-29.9,  $\geq 30$ ). Birth order was categorised into 1, 2 or 3, and  $\geq 4$ . Birth weight was categorised into three groups (< 2500, 2500-3499,  $\geq 3500$  g).

### Follow-up visits

The cohort has been followed on several occasions. In the present analysis we use data from four follow-up visits.

### One year and four years

At one and four years, all low birthweight (< 2500 g) children (n=510) and a sample of 20% of the remainder were sought; 1363 children were seen at one year and 1273 at four years. Weight gains (kg) from birth to 1 year, 1-4 years, and 4-11 years were categorised into quarters. Overweight was defined as weight for height Z scores greater than 2.<sup>5</sup>

### Behavioural substudy at four years

A randomly selected subsample of 634 children followed up at four years was visited. The mother completed a questionnaire.<sup>6</sup> For our study we used the mother's self report on her child's level of physical activity compared with children of the same age and how well her child performed at sports activities.

### 10-12 years

In 2004-5 all cohort members were sought through a school census and population census. Data were collected on physical activity, including mode of transportation to and from school, physical education classes, and leisure time activities. We defined a sedentary lifestyle as less than 300 minutes of physical activity per week, in accordance with current guidelines.<sup>7</sup> We did not include physical education classes because these were of low intensity and carried out only two or three times a week.

We compared the prevalence of sedentary lifestyle across subgroups of the independent variables using  $\chi^2$  tests for heterogeneity and linear trend. Because the variable of minutes per week of physical activity was noticeably skewed, we compared medians using the non-parametric K sample test on the equality of medians (Stata 8.0). We carried out multivariable analyses using Poisson regression.<sup>8</sup>

Variables were included in Poisson regression in accordance with a conceptual framework defined a priori.<sup>9</sup> This model incorporated all perinatal characteristics in the first hierarchical level of determination, variables collected at one year and four years in the second level, and variables collected in the behavioural substudy in the third level. We adjusted variables for other variables in the same and higher levels of determination that presented an association of  $P < 0.20$  with



This is the abridged version of an article that was posted on [bmj.com](http://bmj.com) on 6 April 2006: <http://bmj.com/cgi/doi/10.1136/bmj.38776.434560.7C>

**Table 1** Levels of physical activity in 10-12 year olds according to perinatal variables

Variable	No of participants	% with sedentary lifestyle	P value	Median physical activity score (min/week)	P value
Sex:					
Boys	2167	49.0	<0.001*	300	<0.001†
Girls	2283	67.0		185	
Birth weight (g):					
<2500	398	61.9	0.23‡	210	0.05†
2500-3499	2866	58.1		235	
≥3500	1180	57.5		240	
Family income (No of minimum wages per month):					
≤1	815	54.6	0.001‡	260	0.03†
1.1-3.0	1931	57.6		240	
3.1-6.0	1051	60.1		230	
6.1-10.0	339	59.3		230	
>10.0	315	63.9		190	
Maternal education at birth (years):					
0	105	53.5	0.001‡	270	0.006†
1-4	1133	57.4		240	
5-8	2124	56.2		250	
≥9	1086	63.2		200	
Prepregnancy body mass index:					
<20.0	975	58.1	0.44‡	240	0.83†
20.0-24.9	2364	57.8		240	
25.0-29.9	780	58.6		230	
≥30	220	61.8		210	
Birth order:					
1	1558	58.3	0.002*	230	0.002†
2 or 3	2040	60.3		223	
≥4	853	52.9		270	

\* $\chi^2$  test for heterogeneity. †Non-parametric K sample test on equality of medians. ‡ $\chi^2$  test for trend.

the outcome. Owing to the different sampling fractions of low birthweight and normal birthweight children, we weighted analyses of second and third level variables.

## Results

In 1993, 5265 live births occurred in Pelotas, southern Brazil; 16 mothers refused to participate in a birth cohort study, resulting in a cohort of 5249 children. At follow-up in 2004-5, 4453 (87.5% of total cohort) adolescents were interviewed. See [bmj.com](http://bmj.com) for baseline variables for young people at age 10-12 years. No significant differences were observed for sex and birth weight.

The prevalence of a sedentary lifestyle at 10-12 years was 58.2% (95% confidence interval 56.7% to 59.7%). The median physical activity score was 235 minutes per week (mean 415 (SD 765) minutes per week), showing high skewness.

Male sex, low family income, low maternal education, and high birth order were inversely associated with a sedentary lifestyle at 10-12 years (table 1). No associations were found for birth weight or prepregnancy body mass index.

No significant associations were found with the variables indicating weight gain or overweight in childhood (see [bmj.com](http://bmj.com)). Children classified by their mothers as average or above average for physical activity at 4 years were more likely to be active at 10-12 years (see [bmj.com](http://bmj.com)). No significant effect of sports performance at 4 years was observed.

The effects of sex, maternal education, and birth order did not change after adjustment (table 2).

Although the confidence intervals for all categories of maternal education included unity, there was a logical ordering of the prevalence ratios, and the test for linear trend was significant. For birth order the main difference is between categories 2 or 3 and  $\geq 4$ ; both of these have confidence intervals that include unity, but the overall effect of the variable is still significant. Indicators of weight gain and overweight collected at one and four years remained unrelated to sedentary lifestyles, even after adjustment for perinatal variables. Maternal classification of physical activity at 4 years was still associated with sedentary lifestyle at 10-12 years in the adjusted model.

## Discussion

Social and behavioural variables are more important than early biological characteristics in determining physical activity in adolescence. Identification of possible early determinants is important because a sedentary lifestyle is associated with overweight and several chronic diseases.<sup>10</sup>

We assessed the role of early life factors on physical activity at age 10-12 years within a prospective birth cohort study. Because the samples included at each follow-up were of different sizes, the power to detect differences was greater for perinatal variables than it was for exposures during childhood. Because we failed to find significant associations for some variables, even in the full dataset, and detected some significant associations in the small behavioural sample, lack of statistical power is unlikely to be responsible for our negative results for perinatal variables and data collected at one and four years.

**Table 2** Prevalence ratios (95% confidence intervals) for sedentary lifestyle in 10-12 year olds according to independent variables: crude and adjusted analyses

Variable	Crude analysis: prevalence ratio (95% CI)	P value	Adjusted analysis: prevalence ratio (95% CI)	P value
<b>Level 1: variables collected at perinatal visit (n=5249)</b>				
Sex:				
Boys	1.00		1.00	
Girls	1.37 (1.30 to 1.44)	<0.001*	1.37 (1.30 to 1.44)	<0.001*
Birth weight (g):				
<2500	1.08 (0.09 to 1.18)		1.03 (0.94 to 1.14)	
2500-3499	1.01 (0.95 to 1.07)	0.23†	0.98 (0.93 to 1.04)	0.81†
≥3500	1.00		1.00	
Maternal education at birth (years):				
0	1.00		1.00	
1-4	1.07 (0.89 to 1.30)		1.08 (0.89 to 1.30)	
5-8	1.05 (0.87 to 1.27)	0.004†	1.06 (0.88 to 1.27)	0.006
≥9	1.18 (0.98 to 1.43)		1.18 (0.98 to 1.42)	
Pregpregnancy body mass index:				
<20.0	1.00		1.00	
20.0-24.9	0.99 (0.93 to 1.06)		0.99 (0.93 to 1.05)	
25.0-29.9	1.01 (0.93 to 1.09)	0.44†	1.00 (0.92 to 1.08)	0.45†
≥30	1.06 (0.94 to 1.20)		1.07 (0.96 to 1.21)	
Birth order:				
1	1.00		1.00	
2 or 3	1.03 (0.98 to 1.09)	0.003*	1.03 (0.98 to 1.09)	0.01*
≥4	0.91 (0.84 to 0.98)		0.92 (0.85 to 1.00)	
<b>Level 2: variables collected at one year (n=1363) and four year (n=1273) visits</b>				
Weight gain 0-1 year:				
1st quarter	1.14 (0.99 to 1.31)		1.10 (0.93 to 1.31)	
2nd quarter	1.14 (0.99 to 1.32)		1.19 (1.01 to 1.41)	
3rd quarter	1.09 (0.94 to 1.26)	0.06†	1.14 (0.97 to 1.34)	0.23†
4th quarter	1.00		1.00	
Overweight‡ at 1 year:				
No	1.00		1.00	
Yes	0.90 (0.71 to 1.14)	0.41*	0.90 (0.68 to 1.18)	0.44*
Weight gain 1-4 years:				
1st quarter	0.98 (0.86 to 1.13)		1.00 (0.82 to 1.22)	
2nd quarter	0.97 (0.84 to 1.11)		1.04 (0.86 to 1.26)	
3rd quarter	1.00 (0.87 to 1.15)	0.73†	1.05 (0.88 to 1.25)	0.89†
4th quarter	1.00		1.00	
Overweight§ at 4 years:				
No	1.00		1.00	
Yes	1.09 (0.93 to 1.28)	0.27*	1.12 (0.96 to 1.32)	0.16*
Weight gain 4-11 years:				
1st quarter	1.00 (0.97 to 1.14)		1.04 (0.88 to 1.22)	
2nd quarter	0.89 (0.77 to 1.03)		0.99 (0.85 to 1.17)	
3rd quarter	0.91 (0.79 to 1.05)	0.90*	0.92 (0.79 to 1.08)	0.56*
4th quarter	1.00		1.00	
<b>Level 3: variables collected in behavioural substudy at four years (n=634)</b>				
Mother's report on child's physical activity at four years compared with other children:				
Below average	1.26 (1.01 to 1.56)		1.19 (0.95 to 1.49)	
Average	0.99 (0.79 to 1.23)	0.006*	0.91 (0.72 to 1.15)	0.03*
Above average	1.00		1.00	
Mother's report on child's sports performance at four years compared with other children:				
Below average	1.13 (0.87 to 1.46)		0.98 (0.72 to 1.32)	
Average	1.04 (0.87 to 1.25)	0.65*	0.99 (0.81 to 1.22)	0.88*
Above average	1.00		1.00	

\*Wald test for heterogeneity.  
†Wald test for trend.  
§Weight for height Z scores >2.

The overall follow-up rate (87.5%) is high for studies in a middle income country where participants have to be actively sought.<sup>11</sup> Although statistically significant, the differences in non-response rates according to socioeconomic indicators are unlikely to

have affected the results. The follow-up rates for prepregnancy body mass index ranged from 87% to 92%; this is unlikely to have caused bias because this variable was not associated with the outcome in the adjusted analyses. The prospective nature of the information on early exposures rules out the possibility of recall bias.

Predictors of adolescent physical activity were sex, family income, maternal education, birth order, and reported physical activity at 4 years. In previous studies among adults living in Pelotas, we showed that although upper social class is associated with leisure time physical activity,<sup>12</sup> low social class is associated with non-leisure time physical activities (commuting, occupation, and housework), leading to an overall higher prevalence of sedentary lifestyles among wealthier people.<sup>13</sup> In the present study, active transportation to and from school was much more common among poor adolescents, whereas the opposite was observed for leisure time activities (data not shown), also leading to an overall higher prevalence of sedentary lifestyles among wealthier people.

The effect of birth order on physical activity in adolescents persisted after statistical control for several socioeconomic variables but is difficult to interpret as we lack information on number of siblings. Birth order has been associated with umbilical cord blood concentrations of hormones,<sup>14</sup> which have in turn been linked to infant behaviour.<sup>15</sup> Several studies have reported a positive association between birth order and activity level in young children.<sup>16-17</sup> In our study of adolescents the association was inverse. An alternative explanation is that birth order acted as a proxy for number of siblings. Our results could suggest that a higher number of siblings, irrespective of their activity level, promotes active lifestyles. Brazil is undergoing a noticeable drop in fertility levels<sup>18</sup>; smaller families may thus be contributing to lower levels of physical activity.

Tracking of physical activity from 4 to 10-12 years was significant, despite using a simple variable based on maternal report to determine activity level in childhood. Previous studies have tracked physical activity and fitness from childhood to adolescence, and most found moderate to high positive correlations.<sup>19-20</sup> Such tracking may reflect genetic tendencies or the early establishment of habitual patterns of activity.

Growth acceleration has been linked with obesity,<sup>4</sup> diabetes,<sup>21</sup> hypertension,<sup>2-3</sup> and cardiovascular disease.<sup>22</sup> Because physical inactivity is associated with these conditions,<sup>10-23</sup> a possible pathway could involve lower levels of activity in children who grow rapidly and become overweight. Our data do not support such a hypothesis, suggesting that other pathways are involved. Intrauterine and early life deprivation may increase the risk of chronic disease but do not restrict physical activity; promotion of active lifestyles may at least in part compensate for the higher future risk faced by such children.

Contributors: See bmj.com.

Funding: The Wellcome Trust initiative "major awards for Latin America on health consequences of population change." Earlier phases of the 1993 cohort study were funded by the European Union, the National Program for Centers of Excellence (Brazil), the National Research Council (Brazil), and the Ministry of Health (Brazil).

Competing interests: None declared.

### What is already known on this topic

Interest is currently widespread in the idea of programming of health status by factors operating in early life

Most studies have focused on physiological outcomes, such as blood pressure, diabetes, obesity, and body composition

Behaviours might also be programmed during early critical windows

### What this study adds

Physical activity behaviour in adolescence is partially programmed by social and behavioural factors operating in early life

High birth order and level of physical activity at age 4 years were significant predictors of physical activity in adolescence

The pathway through which early growth acceleration increases the risk of chronic diseases in adulthood does not seem to be mediated by low activity levels

Ethical approval: Federal University of Pelotas Medical School ethics committee, affiliated with the Brazilian Federal Medical Council.

- Parsons TJ, Power C, Logan S, Summerbell CD. Childhood predictors of adult obesity: a systematic review. *Int J Obes Relat Metab Disord* 1999;23:S1-107.
- Forrester T. Historic and early life origins of hypertension in Africans. *J Nutr* 2004;134:211-6.
- Horta BL, Barros FC, Victora CG, Cole TJ. Early and late growth and blood pressure in adolescence. *J Epidemiol Community Health* 2003;57:226-30.
- Monteiro PO, Victora CG. Rapid growth in infancy and childhood and obesity in later life—a systematic review. *Obes Rev* 2005;6:143-54.

- World Health Organization Expert Committee. *Physical status, the use and interpretation of anthropometry*. Geneva: WHO, 1995.
- Achenbach TM. *Manual for the child behavior checklist/4-18 and 1991 profile*. Burlington, VT: University of Vermont, Department of Psychiatry, 1991.
- Biddle S, Cavill N, Sallis J. *Young and active? Young people and health-enhancing physical activity—evidence and implications*. London: Health Education Authority, 1998.
- Barros AJ, Hiraoka VN. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol* 2003;3:21.
- Victora CG, Huttly SR, Fuchs SC, Olinto MT. The role of conceptual frameworks in epidemiological analysis: a hierarchical approach. *Int J Epidemiol* 1997;26:224-7.
- Bauman AE. Updating the evidence that physical activity is good for health: an epidemiological review 2000-2003. *J Sci Med Sport* 2004;7:S6-19.
- Harpham T, Huttly S, Wilson I, De Wet T. Linking public issues with private troubles: panel studies in developing countries. *J Int Dev* 2003;15:353-63.
- Dias-da-Costa JS, Hallal PC, Wells JC, Daltro T, Fuchs SC, Menezes AM, et al. Epidemiology of leisure-time physical activity: a population-based study in southern Brazil. *Cad Saude Publica* 2005;21:275-82.
- Hallal PC, Victora CG, Wells JC, Lima RC. Physical inactivity: prevalence and associated variables in Brazilian adults. *Med Sci Sports Exerc* 2003;35:1894-900.
- Maccoby EE, Doering CH, Jacklin CN, Kraemer H. Concentrations of sex hormones in umbilical blood: their relation to sex and birth order of infants. *Child Dev* 1979;50:632-42.
- Marcus J, Maccoby EE, Jacklin CN, Doering CH. Individual differences in mood in early childhood: their relation to gender and neonatal sex steroids. *Dev Psychobiol* 1985;18:327-40.
- Eaton WO, Chipperfield JG, Singbeil CE. Birth order and activity level in children. *Dev Psychobiol* 1989;25:668-72.
- Wells JCK, Davies PSW. Relationships between behaviour and energy expenditure in 12-week-old infants. *Am J Hum Biol* 1996;8:465-72.
- Barros FC, Victora CG, Barros AJ, Santos IS, Albernaz E, Matijasevich A, et al. The challenge of reducing neonatal mortality in middle-income countries: findings from three Brazilian birth cohorts in 1982, 1993, and 2004. *Lancet* 2005;365:847-54.
- Janz KF, Dawson JD, Mahoney LT. Tracking physical fitness and physical activity from childhood to adolescence: the muscatine study. *Med Sci Sports Exerc* 2000;32:1250-7.
- McMurray RG, Harrell JS, Bangdiwala SI, Hu J. Tracking of physical activity and aerobic power from childhood through adolescence. *Med Sci Sports Exerc* 2003;35:1914-22.
- Ong KK, Dunger DB. Birth weight, infant growth and insulin resistance. *Eur J Endocrinol* 2004;151:S131-9.
- Singhal A, Lucas A. Early origins of cardiovascular disease: is there a unifying hypothesis? *Lancet* 2004;363:1642-5.
- US Department of Health and Human Services. *Physical activity and health: a report from the surgeon general*. Atlanta: National Center for Chronic Disease Prevention and Health Promotion, 1996.

(Accepted 15 February 2006)

doi 10.1136/bmj.38776.434560.7C

## Admissions processes for five year medical courses at English schools: review

Jayne Parry, Jonathan Mathers, Andrew Stevens, Amanda Parsons, Richard Lilford, Peter Spurgeon, Hywel Thomas

### Abstract

**Objective** To describe the current methods used by English medical schools to identify prospective medical students for admission to the five year degree course.

**Design** Review study including documentary analysis and interviews with admissions tutors.

**Setting** All schools (n = 22) participating in the national expansion of medical schools programme in England.

**Results** Though there is some commonality across schools with regard to the criteria used to select future students (academic ability coupled with a “well rounded” personality demonstrated by motivation for medicine, extracurricular interests, and experience of team working and leadership skills) the processes used vary substantially. Some schools do not

interview; some shortlist for interview only on predicted academic performance while those that shortlist on a wider range of non-academic criteria use various techniques and tools to do so. Some schools use information presented in the candidate's personal statement and referee's report while others ignore this because of concerns over bias. A few schools seek additional information from supplementary questionnaires filled in by the candidates. Once students are shortlisted, interviews vary in terms of length, panel composition, structure, content, and scoring methods.

Department of Public Health and Epidemiology, University of Birmingham, Edgbaston, Birmingham B15 2TT

Jayne Parry senior clinical lecturer

Andrew Stevens professor of public health

Richard Lilford professor of clinical epidemiology

continued over



This is the abridged version of an article that was posted on [bmj.com](http://bmj.com) on 16 March 2006: <http://bmj.com/cgi/doi/10.1136/bmj.38768.590174.55>

BMJ 2006;332:1005-9