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Working Paper

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Evidence from Vietnam

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Young Lives, Oxford Department of International Development (ODID), University of Oxford, Queen Elizabeth House, 3 Mansfield Road, Oxford OX1 3TB, UK

Tel: +44 (0)1865 281751 • E-mail: younglives@younglives.org.uk

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Abstract

This paper uses longitudinal data gathered at the ages of 8, 12 and 15 years for nearly 1,000 children born in 1994–95 in Vietnam to investigate their growth between survey rounds and the links between the growth velocities and children's achievement in certain skills. We find that gender and the timing of puberty are the most important determinants of growth velocities. The growth velocities in the periods from 8 to 12 years and from 8 to 15 years of age are statistically significantly associated with cognitive achievement, but not with psychosocial competency. As far as intervention recommendations are concerned, we find that height-for-age at age 8 years is important because the effect of this factor is consistently positive and statistically significant on the major outcomes at the age of 15 years, such as height and cognitive achievement.

The Authors

Le Thuc Duc is a Section Head at the Centre for Analysis and Forecasting at the Vietnam Academy of Social Sciences in Hanoi, and Principal Investigator for Young Lives in Vietnam.

Tran Ngo Minh Tam is a researcher at the Centre for Analysis and Forecasting, and at Paris Dauphine University

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About Young Lives

Young Lives is an international study of childhood poverty, following the lives of 12,000 children in 4 countries (Ethiopia, India, Peru and Vietnam) over 15 years. **www.younglives.org.uk**

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1. Introduction

A recent general survey on nutrition by the National Institute of Nutrition (NIN) of Vietnam and UNICEF shows that three out of ten children under 5 years of age in Vietnam are stunted (NIN and UNICEF 2012). According to an influential body of literature, such as Checkley et al. (2003), de Onis (2003), Walker et al. (1996) and others, these stunted children are expected to be adults with short stature. 'In later childhood these children will subsequently have poor levels of cognition and education, both of which are linked to later earnings … Thus, the failure of children to fulfill their developmental potential and achieve satisfactory educational levels plays an important part in the intergenerational transmission of poverty' (Grantham-McGregor et al. 2007). This presents a major challenge for the development of Vietnam.

Research on the practicability of a remedy for linear growth retardation in early childhood can be traced back as early as Martorell et al. (1992).[1] Some studies imply that in developing country contexts, growth failure is essentially irreversible after about 2 years of age (see Schott et al. 2013, for review). Therefore, to be effective, growth-promoting nutritional interventions should be focused on the first 1,000 days of life (conception to 2 years old). That presents the optimal 'window of opportunity'. Without seeking to undermine the importance of the above 1,000-day opportunity window, however, Prentice et al. (2013) propose considering adolescence as an additional critical opportunity for nutritional intervention. Adolescence is a critical period of accelerated height growth.[2] The most important event that makes the growth in adolescence differ from that in childhood is the adolescent growth spurt, which is related to puberty.[3] The unusually high incremental growth in peak height velocity may lead to changes in children's height-for-age z-score. Fink and Rockers (2014) show that physical growth faltering affected a substantial share of children in the age range 8 to 15 years, with major negative consequences for cognition and schooling outcomes. They find that only '36% of the children stunted at age 8 y[ears] managed to catch up with their peers by age 15 y[ears], and those who caught up had smaller deficits in cognitive scores than did children who remain stunted' (2014: 182).

Deficits in height-for-age for children in Vietnam may be linked to the historical context of the country The parents of the children in this study were born or grew up either during the war against America, which ended in 1975, or in the post-war decade of economic hardship. In fact, short stature can be readily observed among adults in Vietnam. A major survey by the Ministry of Health and the NIN in 2010 shows that the average height of males aged between 22 and 26 years in Vietnam was 164cm, and the corresponding figure for females was 155cm.[4] Young men and women in Vietnam are shorter than their counterparts in neighbouring countries such as China, South Korea, and Thailand, and most of the countries

1 We adopt UNICEF's definitions: early childhood is from birth to approximately 5 or 6 years, and middle childhood approximately from 6 to 12 years (see UNICEF 2009: 35).

2 According to UNICEF (2009: 35), adolescence is from 12 to 18 years (including parts of late childhood and early adulthood).

3 With respect to puberty, what is essentially relevant in this study are the signs of puberty (start of menarche, or changing voice and/or emerging chin hair). These are presented in Section 3.

4 Source: Ministry of Health and NIN (2012), Summary of main findings of general nutrition survey http://viendinhduong.vn/FileUpload/Documents/Ket%20qua%20chu%20yeu%20cua%20Tong%20Dieu%20Tra-Main%20findings%20of%20GNS.pdf

in the world. An improvement in the height of young people in Vietnam is generally desirable. Aiming for that, the Prime Minister's 'Master project of April 2011 for improvement of physical fitness and stature of Vietnamese people for the period 2011–2030' was set up to encourage growth in children and adolescents in Vietnam.[5]

Our motivation started to grow from the findings in Le Thuc Duc and Behrman (2015) on post-infancy growth and educational outcomes in middle childhood. In this paper we look at very similar matters and linkages but work with data on the Young Lives Older Cohort. Specifically, we will identify the factors that are important for changes in height over the periods from 8 to 12 years and from 12 to 15 years of age. The biggest difference between the two papers is which factors of growth the authors focus on. In the former paper, they are most interested in the roles of nutrition and poverty in infancy, while in current study, the factors under consideration include the timing of puberty and the rate of growth before and after it. For the majority of the children sampled, the adolescent growth spurt occurred at some point in the period from 8 to 15 years.

Like the authors in the aforementioned paper, we investigate the impact of growth on cognitive achievement. We find that growth velocity over the period from 8 to 12 years is significantly associated with cognitive achievement at the age of 15, but not with non-cognitive skills. Given that association, and after having found that more than one factor is important for growth in the period from 8 to 15 years, we try answer the question of which of the factors might have significant explanatory power regarding cognitive achievement and psychosocial competency development. The factor to be singled out for that purpose is the timing of puberty.

This paper is organised into five sections, including this introduction. Section 2 describes the background and source of the data used for the analysis. In Section 3 we introduce the methodologies for the estimation of determinants of growth in middle childhood and early adolescence, as well the effect of growth in these periods on cognitive achievement and non-cognitive skills at the age of 15. Section 4 presents the results of the estimations. Finally, we summarise the results and provide concluding remarks in Section 5.

2. Background and sample

In this section, we present some important traits of the population that contains the sample under study. The big picture is relevant for a number of reasons. For instance, anthropometrics of mothers do matter in the growth of their children, at least until the age of 8 years (see, for example, Le Thuc Duc and Behrman 2015). Further, we review literature on adolescent growth and related benchmarks, which will be useful for explanation or justification of growth velocity for the subjects under this study.

2.2 Short stature: an important issue in Vietnam

Anthropometric data for Vietnam demonstrate that the average height of boys and girls increased very slowly over a century-long period. In particular, the average height of 5-year-old boys increased by 4.8cm, from 92.8cm in the 1875 sample to 97.6cm in the 1984 sample (Le Danh Tuyen 2005). For adults, there was almost no change in height over nearly half a

5 This is Prime Minister's Decision No. 641/QĐ-TTg, which set out goals for 2020 that males aged 18 years should reach an average height of 167cm and females 156cm; by 2030 males aged 18 years on average should reach 168.5cm, and females 157.5cm.

century, from 1938 to 1985, during which time the average height of adult males was stable at 160cm and that of adult females at 150–1cm (Le Danh Tuyen 2005). More recently, the Vietnam Living Standard Survey (VLSS) 1992–3 data give the figures of 161.0cm for male adults and 150.8cm for females. The slow growth in stature coincided with times of colonisation, long wars and a post-war decade of unsuccessful economic development.

Since the launch of the economic reforms of Doi Moi, in December 1986, the rate of economic growth has been high. The poverty headcount rate went down to 58 per cent in 1993 and 37.4 per cent in 1998, according to VLSS data. In the years the data used for this study were collected, the economic growth was strong Over the 1986–2006 period, the annual rate of growth of GDP in Vietnam averaged at 7.1 per cent, and GDP in 2006 was about four times that in 1986. The poverty rate in 2006 was as low as 16 per cent. Table 1 presents the results of regression on the height of children in the pre-pubertal growth period (5 to 10 years for girls and 5 to 12.5 years for boys) from VLSS 1992–3 and VHLSS 2006.

Table 1. *Results of regression on height of children born in 1980s and 1990s*

	Coef.	Std. Err.
Male	0.333*	0.177
Age in months	0.406***	0.004
Born after Doi Moi (vs. before)	4.130***	0.167
Constant	74.962***	0.363

Number of observations = 7,375; R^2 = 0.67

The children in VLSS 1992–3 were born before Doi Moi, and the others were born after it. The results of the regression in Table 1 show that the socioeconomic change made a real difference to the health of children. On average, the children in the 2006 sample were 4cm taller than the children of the same age in the 1992–3 sample. Nevertheless, even with significant improvements in children’s health, thanks to economic growth over the two decades since Doi Moi, it remains the case that Vietnamese men and women are of short stature in general. Our results (in Table 1), however, seem to indicate that in middle childhood and before the growth spurt in adolescence, children’s yearly rate of growth was about 5cm, and that fits in with world literature on this matter (for instance, Rogol et al. 2002: 194).

2.2 Review of medical literature on growth in adolescence

2.2.1 Some important facts about adolescent growth: literature on developed countries

As mentioned earlier, we will review the literature on landmarks in puberty and the timing of adolescent growth spurts as a background to our study in this paper. Literature on growth before and after puberty can be found more in the area of health research than in the social sciences. A study on puberty often requires frequent tests/medical examinations. For instance, during the period covered in the paper by Taranger and Hagg (1980), the subjects were examined once a year up to the age of 18 years, and from the age of 10 onwards, their height was recorded every three months. The landmarks documented in the medical papers are useful for social science research, which often work with data gathered in rounds separated by several years. According to Taranger and Hagg, the ‘adolescent period starts with a marked increase in the general growth rate and ends with the termination of growth’ (1980: 57). Prior to that, from the middle of childhood to puberty, growth is relatively stable.

The rule of thumb for the growth in late childhood is 5–6cm per year until puberty (Rogol et al. 2002: 65). Then the pre-pubertal deceleration changes into the adolescent acceleration. According to Tanner,

> The adolescent growth spurt is a constant phenomenon and occurs in all children, though it varies in intensity and duration from one child to another. The peak velocity of growth in height averages about 10cm a year in boys, and slightly less in girls. In boys the spurt takes place on average between 12½ and 15½ years of age and in girls some two years earlier. (Tanner 1981: 43).

The peak height growth velocity is followed by a deceleration period, and then the post-pubertal period. In the post-pubertal period the growth rate changes from 20 mm to 5 mm and then 0 mm per year.[6] The length of the post-pubertal period is in between two and three years (Taranger and Hagg 1980: 62). For girls, the termination of growth may come about half a year after 17 years and that for boys is 19. The above-mentioned landmarks, however, may vary slightly across populations (by country, level of economic development, etc.). Over time, there is evidence of a secular trend in the age of menarche for girls in Europe and the USA (Sandler et al. 1984; Wyshak and Frisch 1982).

Participation in physical activity is often thought a potential factor of growth in adolescence. There is some evidence on delay in growth and sexual maturation among elite female athletes, most notably gymnasts, dancers and long-distance runners (Rogol et al. 2000: 526S). In general, however, Malina (1994) finds that ‘regular physical activity, sport participation, and training for sport has no effect on attained stature, timing of peak height velocity, and rate of growth in stature’ (1994: 765). The studies reviewed in this sub-section are based on samples from European countries.[7] Thus, there can be slight differences between the landmarks documented in the above literature and those to be observed for in the sample in this study.

2.2.2 *Adolescent growth in low-income communities*

Satyanarayana et al. (1980) study 677 boys from 26 villages near Hyderabad, India. The boys were classified as belonging to one of four nutritional groups on the basis of the extent of deficit in height-for-age when they were 5 years of age. Thus, 22 per cent of the boys were normal (non-stunted) and classified as group I. Group IV, on the other extreme, consisted of the severely growth-retarded boys (17.7 per cent). The other two groups comprised boys with mild growth retardation and moderate growth retardation. The authors’ results show that the ‘peak height velocities in the normal (group I) and the severely growth retarded boys (group IV), were essentially similar, the values being 6.8 and 6.9cm/yr respectively’ (1980: 360). The difference, however, was in the age at which the peak height velocity occurred in the two groups. The peak height velocity in the group of the severely growth-retarded boys occurred on average a year later than it did in the group of normal boys. The authors report that ‘height increments over the 150-month period in the four nutritional groups were essentially similar’ (1980: 361). Furthermore, Satyanarayana et al. (1989), find that the growth curves of rural Hyderabad children (boys only) were parallel to the British distance height curve after 12 years of age.[8]

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6 By definition, the end of the post-pubertal period is the first of three consecutive annual increments each being below 5 mm.

7 The Swedish urban children are the subjects in Taranger and Hagg (1980), while sample reviewed in Tanner (1981) are British.

8 The sample in Satyanarayana et al. (1989) is not the same as that in Satyanarayana et al. (1980), at least in size.

Unlike that for males, there is good evidence for adolescent growth catch-up for females. Satyanarayana et al. (1981) examined data from 739 girls aged 12 to 17 years living in the same area as the sample in Satyanarayana et al. (1980). The context is that there were no specific nutritional intervention programmes in these villages. The results show that severely undernourished pre-school girls had between their 5th and 18th year of life gained significantly more height than 'normal' girls. Furthermore, Simondon et al. (1998) studied 1,650 children aged 12 to 17 years with known height-for-age at the age of 2 to 5 years. Their results show that 'the height deficit accumulated during the first years of life by these Senegalese children was not caught up during late childhood or early adolescence, since the increment between 5 and 15 years of age did not differ according to preschool height in either boys or girls' (1998: 415). They observed, however, that some catch-up growth occurred among girls after the age of 15. Simondon et al. (1998) also refer to a claim made in a number of papers that 'catch-up growth occurs through a prolonged growth period, rather than by greater peak height velocities' (1998: 418). Furthermore, Coly et al. (2006) having reviewed the studies that demonstrate catch-up growth, comment that for all of them, catch-up is partial and late (in adolescence). As the subjects under our study are no older than 15, catch-up is not expected to be significant.

2.3 Growth in middle childhood and early adolescence: Young Lives survey data

Since 2002, Young Lives has been following 12,000 children in Ethiopia, India (in Andhra Pradesh), Peru and Vietnam. The study follows two cohorts of children in each country: about 2,000 children born in 2001–2 and another 1,000 born in 1994–5. For most of the analysis in this paper we work with the Older Cohort. To date, the Young Lives has conducted four rounds of child and household surveys in 2001, 2006, 2009 and 2013. We draw on data from Rounds 1 to 3. Thus, the Older Cohort children were aged 8, 12 and 15 years. The period from 8 to 12 years, which is part of middle childhood, will be referred to as Period 1. The one from 12 to 15 years will be referred to as Period 2; this is in fact the early part of adolescence.

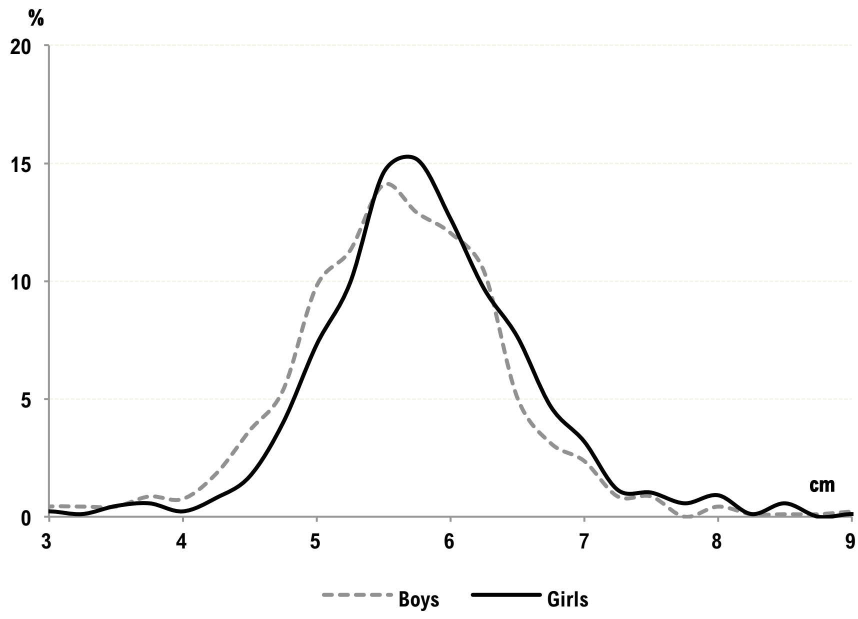
Figure 1 is presented for reference purposes. The data used in this figure are from the Younger Cohort, whose age on average was 5 years in Round 2 (2006). The horizontal axis presents their yearly average growth between Round 2 and Round 3 (2009) in centimetres. The vertical axis presents density, which is formally determined by the following method: at point x,

$$dens|_x = \frac{1m}{N} \times \lim_{\Delta x \to 0} \frac{\Delta y}{\Delta x}$$

where $1m$ presents a unit of length, N is the size of the sample, and Δy is the number of children with the yearly average growth in between x and $x + \Delta x$.[9]

[9] In fact, we ignore the tiny fraction of subjects with velocity greater than 10, and use the unite of length $1m = 100cm$ to converse the density into the number of subjects with velocity within adjacent centimeter and to ensure the $\int_0^{10} dens\, dt = 100$.

Figure 1. *Distribution density of growth velocity from 5 to 8 years*



Source: Young Lives, Younger Cohort data, Rounds 2 and 3

As seen in Figure 1, the graph of growth velocity for the three first years of middle childhood (for the Younger Cohort) resembles that of the normal distribution (according to the literature). In calibre, moreover, it is consistent with Rogol et al. (2002) that from the middle of childhood to the onset of puberty, which varies among individuals, the growth pattern is relatively homogenous. Boys and girls grow about 5 to 6cm per year before adolescence. Unlike Figures 2–4 below, one expects no effect of puberty for the data used in Figure 1.

According to medical literature, around the age of 10 for girls (and two years later for boys), there is a low point in growth velocity before puberty approaches.[10] Then the pre-pubertal deceleration shifts to the adolescent acceleration and that marks the start of the adolescent growth period. 'The onset of puberty corresponds to a skeletal (biological) age of approximately 11 years in girls and 13 years in boys' (Rogol et al. 2002: 195). In the literature, there is good evidence on the variety of the timing of the onset of puberty and of the duration of the growth spurts.

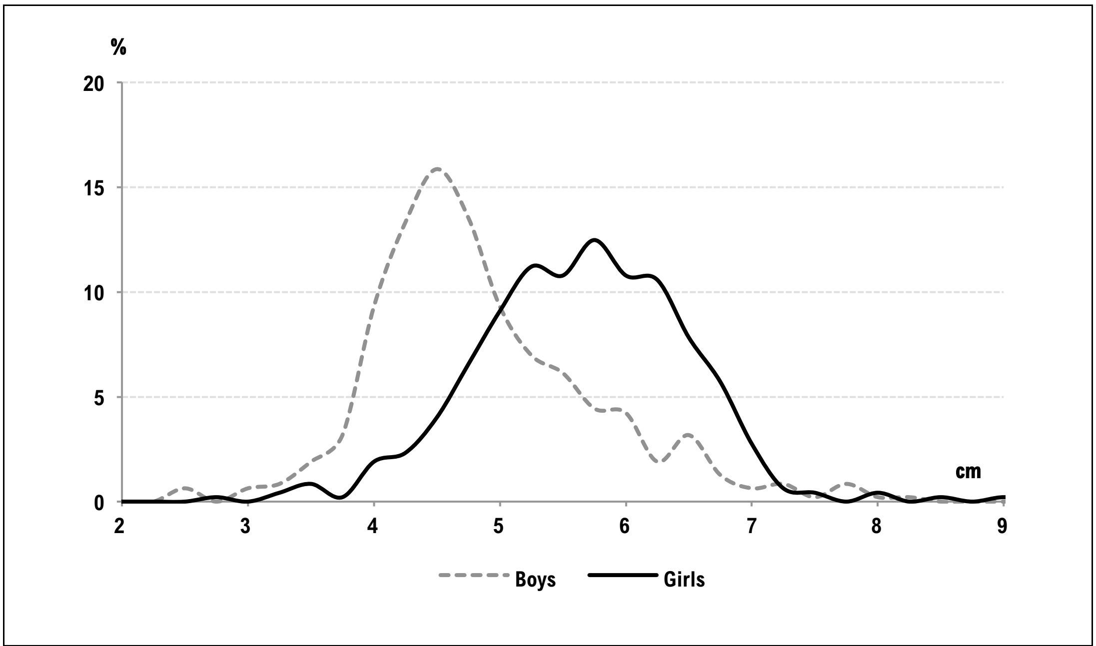
For the sample in this study, evidence shows that for some of children of both genders, a low point in growth had happened before Round 2. Data show that 22 per cent of the girls reported that they had started menarche by Round 2 (aged 12), while only 18 per cent of the boys reported either that their voice had deepened or that they had started growing hair on their chin.

From this point on, however, we use the data from the Older Cohort. The axes in Figures 2–4 are defined in the same way as those in Figure 1. Figure 2 presents the annual average growth of girls and boys for the four last years of middle childhood (ages 8 to 12). What is most easily seen in this figure is the gender difference, unlike in Figure 1. Recall that growth

10 See, for instance, Taranger and Hagg (1980) and Rogol et al. (2002).

slows down before the adolescent spurt, as is implied from what is documented in the medical literature (for example in Taranger and Hagg 1980: 58); that growth velocity is about 50 mm per year in the two years preceding the onset of the peak height velocity; and that it is less than 25 mm per year just after peak height velocity. The growth velocity in Figure 2 is a combination of the pre-pubertal dip and the adolescent growth spurt. We will see later in this study that the boys with favourable height-for-age z-scores at the age of 8 display higher growth in Period 1 than the other boys. In fact, Mills et al. studied boys for over 14 years and found that the boys' 'body size in the first years of life was significantly correlated with the timing of puberty' (1986: 543).

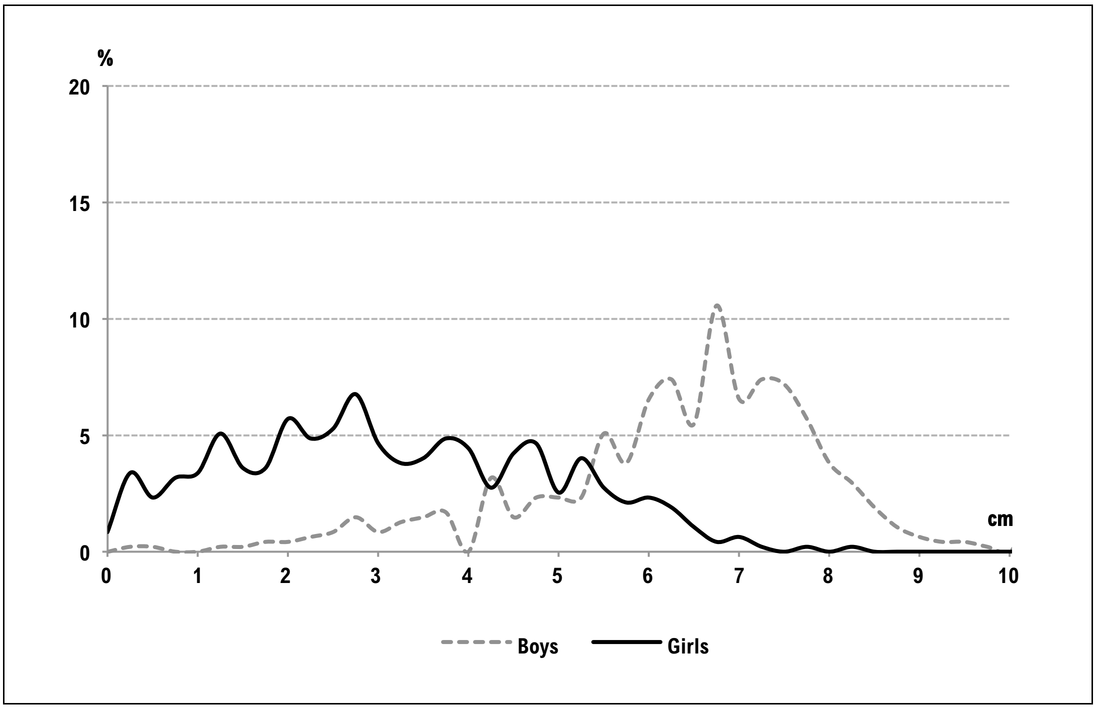
Figure 2. *Distribution density of growth velocity for Period 1*



Source: Young Lives, Older Cohort data, Rounds 1 to 2

Figure 3 presents the average growth velocity for Period 2 (from 12 to 15 years). Data for this period show that about 70 per cent of the boys had a growth velocity of 6cm per year, or higher. On the other hand, about two-thirds of the girls had a growth velocity for this period lower than or equal to 4cm per year. Recall that the average velocity in the first three years of middle childhood is 6cm. Following the literature, for a large proportion of the girls the adolescent growth spurt has ended well before the age of 15 and the very low velocity (20 mm or below) in the later part of Period 2 is the reason that the average growth velocity for Period 2 is lower than the average velocity in the years presented in Figure 1. Figure 3 shows that the growth spurt happens more for boys than that for girls, and that contrasts to what can be deduced from Figure 2.

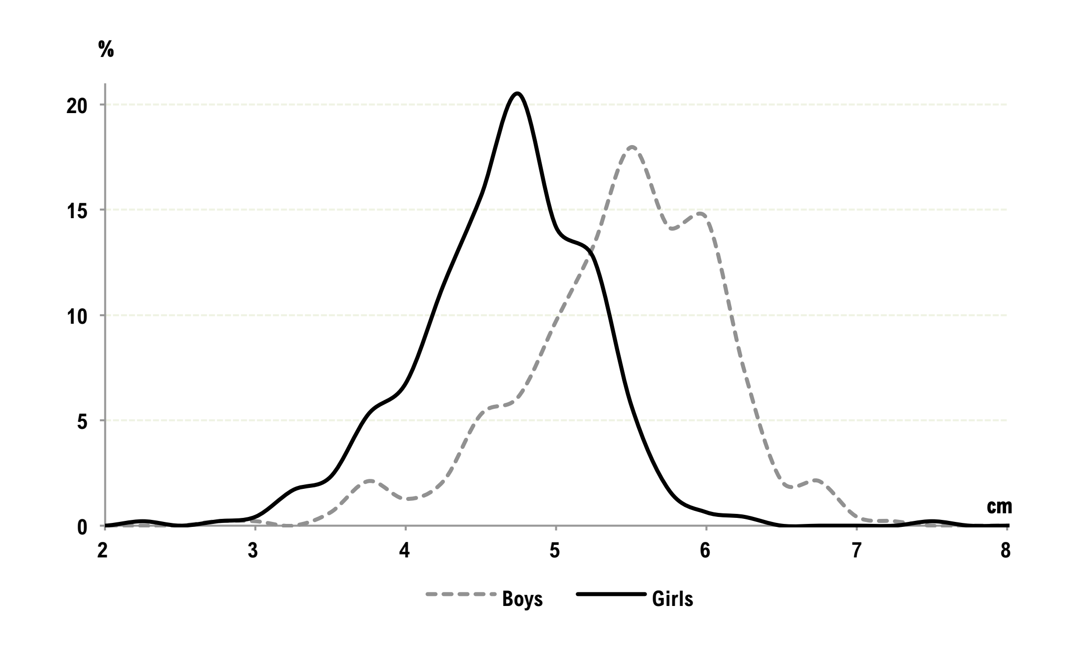
Figure 3. *Distribution density of growth velocity for Period 2*



Source: Young Lives, Older Cohort data, Rounds 2 to 3

Figure 4 presents the distribution density of growth velocity for Period 3, which is Periods 1 and 2 combined, i.e. from 8 to 15 years. Unlike Figure 3, what can be seen in Figure 4 is a greater concentration around the means for both genders. Recall that the adolescent growth spurt has taken place in portions of this seven-year interval, but it makes up for the growth velocity of the whole period, compensating for that in the time intervals preceding and following it (the spurt), especially the latter, if the adolescent growth spurt has ended well before Round 3. Rogol et al. (2002: 195) report that the average height difference of 13cm between adult men and women is the result of boys having a combination of a longer pre-pubertal growth period and greater peak height velocity (10.3cm per year vs. 9cm per year for girls). A calculation shows that the difference in growth accumulated over the period from 8 to 15 years is 5.4cm between the boys and the girls. This difference is smaller than the one documented in Rogol et al. (2002) and can be explained by the fact that the adolescent peak height velocity had not occurred for some of the boys at the age of 15. This gender gap is expected to increase after the adolescent growth spurt is complete for both genders. It is interesting to note that despite the different patterns of the genders in the graphs for Periods 1 and 2, the distributions for the combined periods for boys and girls have similar shapes. It suggests that much of the difference (between the genders) in Period 2 compensates for that in Period 1.

Figure 4. *Distribution density of growth velocity for Period 3 (from 8 to 15)*



Source: Young Lives, Older Cohort data, Rounds 1, 2 and 3

The results of our univariate analysis in this sub-section can be regarded as consistent with the medical literature on adolescent growth. Our aim in this sub-section, however, is not to shed more light on puberty, but to use the literature on puberty growth to explain the growth velocity in late middle childhood and early adolescence. Doing so, we hope to add flavour to the econometric analysis of growth in the years from 8 to 15.

3. Empirical strategy

3.1 The variables

Our analysis uses a number of development outcomes in health and skills. The first outcome is the velocity of growth (measured in cm per year) in Period 1, Period 2, and both periods combined. The set of skill outcomes considered in this study consists of cognitive test scores in maths and receptive vocabulary (Peabody Picture Vocabulary Test – PPVT) and an index of psychosocial competencies to be described below.[11]

Psychosocial competencies are an important part of an adolescent's skills. There are three important measures of psychosocial competencies that can be calculated using Young Lives data. First, *self-efficacy* has been widely studied both theoretically and empirically since it was first introduced by Bandura in 1977 as 'the conviction that one can successfully execute the behaviour required to produce the outcomes' (Rosen et al. 2010). The concept of self-efficacy relates to a person's confidence about whether an outcome is the result of his/her own effort or of luck, fate or the intervention of others (Dercon and Krishnan 2009). The

11 See Cueto and Leon (2012) for more information on the PPVT and maths tests in Round 3.

second psychosocial competency considered in this study is *self-esteem*. Generally, this is a measure of how much a person values or like his/her self. It is distinct from self-efficacy in the sense that self-efficacy is not perceived relative to others (Rosen et al. 2010). Finally, *self-respect and inclusion* focuses on the social component of self-esteem and can be measured through statements that reflect the child's sense of inclusion and pride. In this study, however, we work with a composite index for the psychosocial competencies. The non-cognitive competency composite index is defined as the average of normalised responses for all the statements used to construct the aforementioned psychosocial competencies. Our analysis shows the value of Cronbach's alpha as being 0.72 for Round 2 and 0.80 for Round 3 and that indicates a good reliability for this index (see Appendix A for more information and data on the reliability).

The set of explanatory factors include the child, household and community characteristics, as listed in Table 2. In the Young Lives study, the respondents are not questioned/tested frequently enough for the exact month of the onset of puberty to be identified. The data on puberty is based on the respondents' answers to the question on whether puberty had started by Round 2 (when they were 12). For girls, the question is about whether menarche has started, while for boys, it is about a combination of deepening voice and emerging chin hair.[12] A dummy variable on early puberty, denoted by z, is defined as equal to 1 if, and only if, the girl/boy answers yes to the aforementioned corresponding question. Other characteristics of a child include gender, anthropometric indicators, age in months (at the times of the survey), ethnicity, birth order (the dummy on whether the child is the first child of the mother) and time use. Time use concerns the hours the adolescent spends on work, study and leisure on a regular weekday. Study time includes the hours spent at school as well as the hours spent doing homework and attending extra classes that are not part of official classes in school. Following Cunha and Heckman's technology of cognitive and non-cognitive skill formation (2008), study time can be interpreted as parental investment. The alternative uses of time in Round 2 of the Young Lives survey included *work* and *general leisure*. The former can be interpreted as parental disinvestment. It includes unpaid work on the family farm, cattle herding, looking after animals, and other family business activities, as well as paid work in the labour market. This category of activities, however, does not include household chores and care for other household members. Finally *general leisure*, by definition, includes time spent on playing, seeing friends, using the internet, etc.

12 These developments need not mark the onset of puberty, but rather they indicate that puberty has started by Round 2 (see Ahmed et al. 2009: 238, for definition of Tanner puberty stages).

Table 2. *Descriptive statistics of variables*

Variable	Mean	Std. Dev.
If a boy	0.50	0.50
HAZ at age 8 years	−1.40	0.96
Body mass index (BMI), Round 1	14.2	1.33
Age (months), Round 2	147.6	3.95
Age (months), Round 3	181.2	3.81
Height (cm), Round 1	118.7	5.61
Height (cm), Round 2	141.7	7.80
Shows signs of puberty by Round 2 (age 12 y.)	0.20	0.40
Growth velocity		
in Period 1 (R1 to R2)	5.39	1.00
in Period 2 (R2 to R3)	4.80	2.3
in Period 3 (R1 to R3)	5.16	0.74
Ethnic minority	0.13	0.33
If first child of the mother	0.37	0.48
Maths score, Round 2	7.43	1.92
Maths score, Round 3	18.0	7.4
PPVT score, Round 2	137.5	26.2
PPVT score, Round 3	167.1	28.2
Non-cognitive index, Round 2	−0.01	0.44
Non-cognitive index, Round 3	0.00	0.47
Time use		
study, Round 2	8.81	2.09
work, Round 2	0.69	1.36
leisure, Round 2	5.73	1.96
study, Round 3	7.24	4.03
work, Round 3	1.62	2.86
leisure, Round 3	4.82	2.22
Mother's height (cm)	148.9	29.4
Mother completed lower secondary education	0.42	0.49
Father completed lower secondary education	0.51	0.50
Wealth index, Round 1	0.45	0.21
Region		
Northern Uplands	0.20	0.40
Red River Delta	0.20	0.40
Rural Central Coast (omitted category)	0.20	0.40
Mekong Delta	0.20	0.40
Urban	0.19	0.39

Source: Young Lives, Older Cohort data, Round 2

Household characteristics in this study consist of the wealth index, mother's height, and a dummy variable on parents' school attainment.[13] For mother (father), the dummy variable equals 1 if the mother (father) has completed lower secondary education. Finally, we use a dummy variable to present urban (vs rural) location, and three dummy variables to present regions. The regional dummy variables are Northern Uplands, Red River Delta, and Mekong Delta. The rural sector of Central Coast region is used as baseline, which features as the omitted category.

3.2 Empirical strategy

The two main questions we try to answer in this study of adolescent growth are the following: (i) Which factors are important for the changes in the height of respondents? and (ii) Is there any impact of growth in middle childhood and/or early adolescence on either cognitive or non-cognitive skill development? In what follows, we describe the production functions to be used to answer these research questions. Let x_{ik} represent the characteristics (other than the outcomes) for child i, with $k = 1, K$. Further, let $y_{il}, l = 1, L$ be household characteristics and commune characteristics, which are the dummies on urban (vs rural) and regions. To answer the first research question, we estimate the following health production function (1)

$$\Delta h_i^j = \alpha^j + \sum_{k=1}^{K} \gamma_k^j x_{ik} + \sum_{l=1}^{L} \delta_l^j y_{il} + u_i^j \qquad (1)$$

where Δh^j is the growth velocity over periods, which can be one of three scenarios: (i) $j = 1$: for Period 1 (from age 8 to 12 years); (ii) $j = 2$: for Period 2 (12 to 15 years), and (iii) $j = 3$: for the combination of two periods. Error terms $u^j$are assumed to be white noise. In the above equation, the child, household and community characteristics refer to a specific time.

To investigate the effect of adolescent growth on cognitive achievement and non-cognitive competencies, we apply an approach similar to that in Sánchez (2013), who extends the framework by Cunha and Heckman (2007) and Cunha and Heckman (2008). Let c_{it}^s be measures of skill $s, s = 1, S$, each of which can be a cognitive test score, or the composite index of the non-cognitive skills for child i in Round t, where *t*=2 and *t*=3. Furthermore, x_{ik}, $k = 1, K$ are the child characteristics and $y_{il}, l = 1, L$ the household characteristics and commune characteristics. For each of the skill outcomes $s = 1, S$, we estimate the following production function:

$$c_{i3}^s = \bar{\alpha}^s + \mu_j^s \Delta h_i^j + \sum_{r=1}^{S} \beta_r^s c_{i2}^r + \sum_{k=1}^{K} \bar{\gamma}_k^s x_{ik} + \sum_{l=1}^{L} \bar{\delta}_l^s y_{il} + \varepsilon_i^s \qquad (2)$$

where, $j = 1$, or $j = 3$; Δh^1 and Δh^3 are the growth densities in Periods 1 and 3, for which the density distributions of growth velocity are close to normal distribution. In another version, Δh^2 features additionally as one of the explanatory factors. The error term ε is assumed to be white noise. Note that the sum $\sum_{r=1}^{S} \beta_r^s c_{i2}^r$ presents the total influences of the all the lagged skill outcomes (in Round 2) on skill s in Round 3.

Furthermore, we focus on one of the important determinants of growth velocity. As will be seen when we present the results of the estimation for the production functions (1) and (2), the timing of puberty is a statistically significant factor in growth velocity in Period 1, and the

13 The wealth index is the simple average of three components: (1) housing quality, which is the simple average of scaled rooms per person, floor, roof and wall; (2) the value of consumer durables, which is the scaled (0 to 1) sum of nine dummies for the basic consumer durables. The set of basic consumer durables is radio, refrigerator, bicycle, motorcycle, car, mobile phone, land line phone, fan, and television; (3) the value of services, which is the simple average of drinking water, electricity, sanitation facilities, and fuel, all of which are 0–1 variables. See http://www.esds.ac.uk/doc/5307/mrdoc/pdf/5307methodology_r1.pdf for further information.

latter (the growth velocity in the Period 1) is significantly associated with cognitive achievement in Round 3. Thus, it makes sense to try to estimate the association between the timing of puberty and the achievement in skills. The following equation will be estimated:

$$c_{i3}^{s} = \hat{\alpha}^{s} + \rho z_i + \sum_{r=1}^{S} \hat{\beta}_r^s \, c_{i2}^{r} + \sum_{k=1}^{K} \hat{\delta}_k^s \, x_{ik} + \sum_{l=1}^{L} \hat{\varphi}_i^s \, y_{il} + v_i^s \quad (3)$$

where z is the dummy 'shows signs of puberty by the age of 12 years'. This is among the child characteristics in the above health production function (1), but it features formally differently in equation (3), replacing growth velocity in equation (2). Again, the error term v is assumed to be white noise. All the models in this study will be estimated by the method of ordinary least squares (OLS).

4. Empirical results

4.1 The determinants of growth velocities

The results of OLS regressions for the health production function (1) are presented in Table 3. There are two sets of results for growth velocity: for Period 1 and for the combined period (Period 3). Early occurrence of puberty is positively associated with velocity of growth in Period 1, but negatively associated with growth velocity in Period 3 (from 8 to 15 years), but it is not statistically significant for boys in the latter period. Thus, the girls with delayed puberty are more likely to gain height by the age of 15 than the girls showing signs that puberty had started by Round 2. One may interpret the fact that the effect of early puberty on the growth over the seven-year period is significant only for girls as the following: for girls, there is a factor of delay (or slight delay) if menarche had not started by the age of 12, but for boys not having started puberty by the age of 12 does not mark a delay of puberty.

Age is important, as the older the subject was (when interviewed in Round 3), the greater the likelihood of the post-pubertal spell beginning by Round 3 (or the longer the post-pubertal spell), and that contributes to lower velocity in the whole period. Furthermore, Table 3 shows the statistically significant effect of height-for-age at the age of 8, for both genders, in Period 3, but the effect of this health factor in Period 1 is significant only for boys, not for girls. For another measure of health, which is height in Round 3, however, as can be seen from Table A3 in the Appendix, the effect of height-for-age Round 1 is statistically significant and positive for both genders.

Table 3. *Determinants of growth velocity from 8 to 15 years (in Periods 1 and 3), by gender*

	Boys		Girls	
	8 to 12 years	8 to 15 years	8 to 12 years	8 to 15 years
Shows signs of puberty by age 12 years	0.445***	-0.034	0.268**	-0.463***
	(0.112)	(0.088)	(0.111)	(0.067)
Age at the end of period (months)	-0.003	-0.021**	0.016	-0.029***
	(0.011)	(0.009)	(0.010)	(0.007)
Height-for-age z-score at 8 years	0.245***	0.106***	0.038	-0.144***
	(0.047)	(0.038)	(0.047)	(0.029)
BMI at 8 years	0.072**	-0.037	0.023	-0.031
	(0.032)	(0.025)	(0.032)	(0.020)
Ethnic minority	-0.230	-0.149	-0.225	-0.116
	(0.156)	(0.123)	(0.176)	(0.104)
If first child of mother	0.257***	0.202***	-0.073	-0.024
	(0.087)	(0.068)	(0.086)	(0.052)
Study time in the latest round[a]	0.042*	0.011	-0.015	0.005
	(0.023)	(0.020)	(0.023)	(0.015)
Work time in the latest round	-0.022	0.014	-0.065*	-0.005
	(0.038)	(0.021)	(0.038)	(0.017)
Leisure time in the latest round	-0.027	0.024	-0.030	-0.000
	(0.024)	(0.024)	(0.025)	(0.019)
Mother's height	-0.001	-0.001	0.003	0.001
	(0.001)	(0.001)	(0.002)	(0.001)
Mother completed lower secondary education (LSE)	-0.178	0.064	0.096	-0.061
	(0.110)	(0.087)	(0.103)	(0.063)
Father completed LSE	0.255**	0.164**	0.029	-0.090
	(0.104)	(0.082)	(0.108)	(0.067)
Wealth index, Round 1 (normalised)	0.142**	0.013	-0.014	0.021
	(0.068)	(0.054)	(0.066)	(0.040)
Urban	-0.027	-0.191*	-0.072	-0.098
	(0.149)	(0.115)	(0.152)	(0.093)
Northern Uplands	0.207	-0.106	-0.017	0.087
	(0.154)	(0.119)	(0.142)	(0.086)
Red River Delta	-0.167	-0.190*	-0.219	0.040
	(0.147)	(0.114)	(0.140)	(0.085)
Mekong Delta	0.039	-0.284**	0.144	0.006
	(0.154)	(0.116)	(0.141)	(0.086)
Number of observations	423	423	437	437
R-squared	0.28	0.11	0.09	0.33

Note: Standard errors are in parentheses, underneath the estimated coefficients; *** p<0.01, ** p<0.05, * p<0.1

[a] The latest round is Round 2 for Period 1 (columns 1 and 3) and Round 3 for Period 3 (columns 2 and 4).

The estimation of health production for the whole sample is presented in Table A2 in the Appendix, in which the dummy male is used to control for the difference between the genders. It can be seen in Table A2 that even after having controlled for the anthropometrics, the gender factor remains important. The figures indicate that growth in Period 1 is greater for girls than for boys. On the average, girls' growth is 7 mm per year more than that of boys in Period 1. The opposite effect, but with greater magnitude is found in Period 2. Over the years from 12 to 15, the growth velocity is greater for boys than for girls by as much as 3cm per year. As a result, in the two periods, the boys gain more in height than the girls by about 8cm, other things being equal.

Unlike in early childhood, the biological characteristic of mother height has virtually no impact on growth velocity in late middle childhood and early adolescence, as far as our sample is concerned. That contrasts with its impact on growth in the period from 1 to 8 years, as documented in Le Thuc Duc and Behrman (2015) where the authors show that the height of the mother was a major factor in her child's growth up to the age of 8 years. Further, it can be seen that neither the school attainment of the mother, nor that of the father has any effect on the velocity of growth of girls. For boys, however, education of father has positive significant effects on growth velocity in Period 1, as well as in Period 3. Finally, the effect of household wealth index is statistically significant for boys. For girls, however, we find only three factors are important determinants of growth velocity over the period from 8 to 15 years. These factors are the timing of puberty, their age (in months) in Round 3, and their height-for-age at the age of 8. This is consistent with the results in Table A3, which also shows that for both genders, having controlled for height at age 8 years, the impact of socioeconomic status in Round 1 (when the children were 8) on height at the age of 15 is negligible.

4.2 Growth and skill development

Table 4 presents the estimation for skill production functions (2). For ease of interpretation, the scores in the cognitive tests are normalised to be in terms of standard deviations. We are most interested in the effect of growth velocity on skills in Period 3 (from 8 to 15 years), because the distribution of growth velocity came reasonably close to a normal distribution, and the shapes of distribution for boys and for girls were similar (see Figure 4). The estimates for the effect of growth velocity in other periods are presented in Tables A4 and A5 in Appendix.

The figures in the first two columns of Table 4 indicate statistically significant association between growth velocity and cognitive outcomes (i.e. maths and PPVT scores) in Round 3. With respect to non-cognitive skills (see the last column), we find no such significant association. The results presented in Table A4 in Appendix B are for a modified version of function (2), with growth velocities in both Periods 1 and 2 featuring. The purpose of this exercise is to show that the association is significant for the growth velocity in Period 1, but not in Period 2. Together with the estimates in Table A5, it implies that the significance of the association between growth in Period 3 and cognitive achievement is contributed mainly by the impact of growth between 8 and 12 years rather than that in the period from 12 to 15 years.

Table 4. *Estimations for the effect of growth velocity in Period 3 (8–15 years) on cognitive and non-cognitive skills*

	Maths R3	PPVT R3	Non-cognitive
Growth velocity in Period 3	0.099**	0.085**	-0.001
	(0.045)	(0.043)	(0.026)
Maths score R2, normalised	0.340***	0.073*	-0.035
	(0.041)	(0.039)	(0.024)
PPVT score R2, normalised	0.114***	0.340***	0.057**
	(0.042)	(0.040)	(0.024)
Non-cognitive index, R2	0.206***	-0.028	0.128***
	(0.063)	(0.060)	(0.037)
Male	-0.206***	-0.034	0.010
	(0.066)	(0.063)	(0.038)
Age (months), Round 3	0.001	0.000	0.003
	(0.008)	(0.007)	(0.004)
Height-for-age z-score at 8 years	0.079**	0.081***	-0.021
	(0.032)	(0.030)	(0.018)
BMI at 8 years	0.016	0.005	0.009
	(0.021)	(0.020)	(0.012)
Ethnic minority	0.194*	-0.440***	-0.167**
	(0.114)	(0.108)	(0.066)
If first child of mother	-0.019	-0.022	-0.001
	(0.056)	(0.053)	(0.032)
Study time, R3	0.054***	0.031*	0.035***
	(0.017)	(0.016)	(0.010)
Work time, R3	-0.009	-0.023	-0.002
	(0.019)	(0.018)	(0.011)
Leisure time, R3	-0.013	0.016	0.018
	(0.020)	(0.019)	(0.012)
Mother completed lower secondary education (LSE)	0.159**	-0.104	0.008
	(0.069)	(0.066)	(0.040)
Father completed LSE	-0.038	0.027	-0.027
	(0.070)	(0.067)	(0.041)
Wealth index, Round 1 (normalised)	0.095**	0.108**	0.050*
	(0.045)	(0.042)	(0.026)
Urban	0.157	0.093	-0.062
	(0.099)	(0.094)	(0.057)
Northern Uplands	-0.032	0.096	0.242***
	(0.098)	(0.093)	(0.056)
Red River Delta	-0.063	0.054	-0.042
	(0.092)	(0.088)	(0.053)
Mekong Delta	0.239**	-0.122	0.168***
	(0.095)	(0.090)	(0.055)
Number of observations	790	790	790
R-squared	0.45	0.43	0.16

Note: Standard errors are in parentheses, underneath the estimated coefficients; *** p<0.01, ** p<0.05, * p<0.1

The effects of lagged outcomes are found to be broadly consistent with the findings of Sánchez (2013); that is, self-productivity (the coefficient for the same outcome in Round 2)of each of the skills considered in this study is statistically significant. So is the cross-productivity in the sense that one of the lagged cognitive skills (the PPVT score in Round 2) reinforced non-cognitive skills in Round 3, and in the opposite direction – the effect of non-cognitive skills in Round 2 on maths score in Round 3 is statistically significant. Both self-productivity and cross-productivity for the (lagged) non-cognitive index in this study are inconsistent with the findings of Helmers and Patnam (2011), who use Young Lives data from India. Earlier, Cunha and Heckman (2008), working with US data, found evidence of self-productivity and the cross-productivity in only one direction, which is from non-cognitive to cognitive skills.

Evidence shows that girls performed better than boys in the maths test. With respect to the receptive vocabulary score, and all the non-cognitive skills, the gender gap is insignificant in both a statistical and an economic sense. Height (but not body mass index) at the age of 8 has an impact on cognitive achievement at the age of 15. Study time has a positive effect on both cognitive and non-cognitive outcomes. One possible explanation for this is that the children attending school in general perform better than the children who have left or have never attended school. Furthermore, child work time is consistently negatively associated with all the outcomes, although the magnitude is very small and not statistically significant.

The children whose mothers completed the lower secondary school do better in maths. That can be seen clearly also in Tables A4 and A5 in Appendix B. Other than that, parental school attainment has little impact on children’s skills. Finally, the effect of the wealth index is most consistently found statistically significant for all the skill outcomes. As the wealth index in Round 1 is a measure of poverty/prosperity, it implies that poverty in the early years can have a long-term impact on the development of all the skills under consideration.

4.3 Timing of puberty and skill development

We now narrow the focus of our attention to one of the major factors of growth velocity in Period 1; that is the dummy variable on whether puberty had started by Round 2. It makes sense to look more deeply into which variables are associated with the variable on the timing of puberty. It can be seen in Table A6 in Appendix that for girls, apart from the urban factor, only height and weight in Round 1 are important. For boys, the body mass index in Round 1, and the regional dummies are the only important factors. Thus socioeconomic status has little impact on timing of puberty.

In Table 5 we present the estimates for equation (3). The results of OLS regressions show that the effect of timing of puberty is not statistically significant for any of the skills. In economic terms, the effect of the variable ‘shows signs of puberty by Round 2’ is quite low in comparison with the corresponding figure in Table 4 and the estimate for the growth velocity in Period 1 (see Table A4). Recall that the mean value for the corresponding variable in Table 4, which is the growth velocity in Period 3, equals 5.16, while that for the variable on the timing of puberty equals 0.20. With the only exception being the effect of the variable in focus (‘Shows signs of puberty by Round 2’), the estimates for the factors in Table 5 are qualitatively the same as the corresponding ones in Table 4.

Table 5. *Estimations for the effect of the timing of puberty on cognitive and non-cognitive skills*

	Maths R3	PPVT R3	Non-cognitive
Shows signs of puberty by Round 2	0.064	-0.005	-0.058
	(0.071)	(0.067)	(0.041)
Maths score, Round 2, normalised	0.346***	0.078**	-0.035
	(0.041)	(0.039)	(0.023)
PPVT score, Round 2, normalised	0.118***	0.343***	0.058**
	(0.042)	(0.040)	(0.024)
Non-cognitive index, Round 2	0.210***	-0.026	0.126***
	(0.064)	(0.060)	(0.037)
Male	-0.119**	0.038	0.006
	(0.054)	(0.052)	(0.031)
Age (months), Round 3	-0.002	-0.002	0.004
	(0.007)	(0.007)	(0.004)
Height-for-age at 8 years	0.071**	0.077**	-0.018
	(0.032)	(0.031)	(0.019)
BMI at 8 years	0.006	0.000	0.012
	(0.021)	(0.020)	(0.012)
Ethnic minority	0.185	-0.444***	-0.162**
	(0.114)	(0.108)	(0.066)
If first child of mother	-0.014	-0.017	0.000
	(0.056)	(0.053)	(0.032)
Study time, Round 3	0.056***	0.032**	0.034***
	(0.017)	(0.016)	(0.010)
Work time, Round 3	-0.008	-0.022	-0.001
	(0.019)	(0.018)	(0.011)
Leisure time, Round 3	-0.009	0.018	0.017
	(0.021)	(0.019)	(0.012)
Mother completed lower secondary education (LSE)	0.155**	-0.105	0.011
	(0.069)	(0.066)	(0.040)
Father completed LSE	-0.045	0.024	-0.025
	(0.070)	(0.067)	(0.040)
Wealth index, Round 1 (normalised)	0.092**	0.108**	0.053**
	(0.045)	(0.043)	(0.026)
Urban	0.134	0.079	-0.056
	(0.099)	(0.094)	(0.057)
Northern Uplands	-0.023	0.095	0.232***
	(0.099)	(0.094)	(0.057)
Red River Delta	-0.059	0.047	-0.052
	(0.093)	(0.089)	(0.054)
Mekong Delta	0.219**	-0.138	0.170***
	(0.095)	(0.090)	(0.055)
Number of observations	790	790	790
R-squared	0.45	0.43	0.16

Note: The standard errors are in parentheses, underneath the estimated coefficients; *** p<0.01, ** p<0.05, * p<0.1

5. Summary and discussion

Working with data on the growth of children aged 8 to 15 in Vietnam, one could have expected different findings from those prevalent in the literature, which in most cases is based on samples from countries outside east Asia. However, the evidence that we come up with on growth in the period from late part of middle childhood into adolescence are largely consistent with the literature, rather than otherwise. We find that the timing of puberty makes a major difference to growth, not only in the period from 8 to 12 years, but also in the total growth from 8 to 15 years. The children with no sign of puberty by the age of 12 years gain more height by the age of 15 years than the others. That is particularly evident for girls, and at the age of 15 years, the girls with delayed puberty tend to be taller than the other girls. Furthermore, evidence shows a major difference in the pattern of growth between boys and girls. Height and weight at the age of 8 are important for the yearly average growth over the period from 8 to 12 years for boys, but not for girls. Moreover, the effect of height-for-age at the age of 8 on growth from 8 to 15 years is positive for boys, but negative for girls.

Notwithstanding, there are some important facts that both genders share. The first is that despite the fact that the effect of height-for-age at the age of 8 on growth velocity is mixed, its effect on height in Round 3 (at the age of 15) is consistently positively and statistically significant. Secondly, simply but importantly that, unlike in the years up to age of 8, growth in the years between 8 and 15 years has no link to the biological characteristic of mother height. Finally, the pattern of time use has little impact on growth in in middle childhood and early adolescence (from 8 to 15 years).

This study shows that growth velocity in the period from 8 to 12 years, and that from 8 to 15 is statistically significantly associated with children’s cognitive achievement at the age of 15 years, both in maths and in receptive vocabulary, but not with psychosocial competencies. We do not interpret the association between adolescent growth and skill development as causal. That is because there could be unobserved factors that correlate to the growth velocity and the skill outcomes. Furthermore, we look closely at the factor of puberty, which is a major factor of growth in the period from 8 to 12 years. It turns out that the timing of puberty is not significantly associated with any of the cognitive and non-cognitive skills at the age of 15 years.

As far as policy is concerned, we find the factor of height-for-age at age 8 years the most important thing. The effect of this factor is positively statistically significant on both cognitive achievement and height at the age of 15. Height at the beginning of middle childhood is the accumulated growth of the previous years, but nutrition in the first couple of years is critical (see Le Thuc Duc and Behrman 2015). The findings of this study, thus, provide further support for early interventions to reduce infant stunting.

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Appendix A: Method for calculation of the composite index for non-cognitive skills

We apply the method used in Dercon and Sánchez (2013) to calculate the measure of non-cognitive skills in this paper. Instead of computing each individual non-cognitive skill, including self-efficacy, self-esteem and self-respect and inclusion – see Dercon and Krishnan (2009), Dercon and Sanchez (2011), Dercon and Sánchez (2013) and Sánchez (2013) for detailed definitions and measurement of the skills – we aggregate these skills into a composite variable. The non-cognitive skill index is therefore the average of normalised responses for all the statements used to construct the above-mentioned skills.

The aggregation of these skills into one variable is justified because self-efficacy and self-esteem are traits related to the 'Neuroticism/Emotional Stability' factor in the Big Five or Five Factor Model (Almund et al. 2011),[14] and 'self-respect and inclusion' is another name for of self-esteem (Blascovich and Tomaka 1991), which focuses on the social component of self-esteem (Dercon and Krishnan 2009).

Excluding the items with mostly missing responses, all remaining items for constructing such psychological competencies as self-efficacy, self-esteem and self-respect and inclusion, are entered in the composite indices in Rounds 2 and 3. All the items are recoded to reflect positive statements. The degree of agreement with these statements, which is based on a 4-point Likert scale (in Round 2) and 5-point Likert scale (in Round 3), is also recoded to range from strong disagreement to strong agreement. Our non-cognitive indices are reliable, because the Cronbach's alpha we obtain from our analysis is 0.72 and 0.80 for the non-cognitive index in Round 2 and Round 3 respectively. Table A1 shows the Cronbach's alpha for the all items in the non-cognitive skill index, which obtain the value of at least 0.7.

14 Inclusive of Openness to Experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism.

Table A1. *Cronbach's alpha for the psychosocial competencies*

	Round 2	Round 3
Self-efficacy		
If I try hard I can improve my situation in life	0.71	0.79
Other people in my family make all the decisions about how I spend my time	0.73	0.81
I like to make plans for my future studies and work	0.71	0.79
If I study hard at school I will be rewarded by a better job in future.	0.71	0.81
I have a choice about the work I do.	-	0.78
Self-esteem		
I am proud of my clothes	0.69	0.79
I am proud because I have the right books, pencils or other equipment for school	0.70	0.78
I am proud of my shoes or of having shoes	0.69	0.79
I am proud that I have the correct uniform	0.71	0.78
I am proud of the work I have to do	-	0.81
I feel proud to show my friends or other visitors where I live.	0.70	-
I feel proud of the job done by the head of household.	0.71	-
I am proud of my achievements at school.	0.71	-
Self-respect and inclusion		
When I am at the shops/market I am usually treated by others with fairness and respect	0.70	0.80
Adults in my community treat me as well as they treat other children of my age	0.70	0.78
The other children in my class treat me with respect.	0.70	0.79
Other pupils in my class tease me at school.	0.71	0.78
My teachers treat me as well as they treat other children.	0.71	
My friends will stand by me during difficult times		0.79
I feel I belong at my school		0.79
My friends look up to me as a leader		0.78
I have people I look up to		0.79
I have opportunities to develop job skills		0.78

Appendix B: Supporting tables

Table A2. *Determinants of growth velocity: All periods, whole sample*

	Period 1	Period 2	Period 3
Shows signs of puberty by 12 y.	0.305***	-1.102***	-0.307***
	(0.078)	(0.131)	(0.057)
Age at the end of period (months)	0.007	-0.083***	-0.026***
	(0.008)	(0.013)	(0.006)
Height-for-age at the start of period	0.139***	-0.535***	-0.022
	(0.034)	(0.051)	(0.025)
BMI at 8 y.	0.037	-0.146***	-0.045***
	(0.023)	(0.038)	(0.017)
Male	-0.715***	3.090***	0.790***
	(0.059)	(0.097)	(0.043)
Ethnic minority	-0.239**	-0.087	-0.133
	(0.117)	(0.192)	(0.084)
If first child of mother	0.094	0.124	0.089**
	(0.062)	(0.101)	(0.044)
Study time in the latest rounda	0.015	0.015	0.010
	(0.017)	(0.029)	(0.013)
Work time, in the latest round	-0.041	0.041	0.005
	(0.027)	(0.033)	(0.014)
Leisure time in the latest round	-0.028	0.034	0.015
	(0.017)	(0.036)	(0.016)
Mother height	0.000	0.000	-0.000
	(0.001)	(0.002)	(0.001)
Mother completed lower secondary education (LSE)	-0.009	0.078	0.008
	(0.076)	(0.127)	(0.056)
Father completed LSE	0.105	-0.053	0.000
	(0.076)	(0.127)	(0.056)
Wealth index, Round 1 (normalised)	0.070	0.031	0.030
	(0.048)	(0.080)	(0.035)
Urban	-0.030	-0.298*	-0.142*
	(0.107)	(0.176)	(0.077)
Northern Uplands	0.089	-0.124	-0.020
	(0.106)	(0.173)	(0.076)
Red River Delta	-0.212**	-0.030	-0.114
	(0.102)	(0.169)	(0.074)
Mekong Delta	0.091	-0.348**	-0.161**
	(0.105)	(0.169)	(0.075)
Number of observations	860	860	860
R-squared	0.28	0.64	0.34

Notes: The standard errors are in parentheses, underneath the estimated coefficients; *** p<0.01, ** p<0.05, * p<0.1
[a] The latest round is Round 2 for Period 1 (columns 1) and Round 3 for Periods 2 and 3 (columns 2 and 3).

Table A3. *Determinants of height in Round 3*

	Boys	Girls
With sign of puberty by age 12 y.	-0.189	-3.126***
	(0.622)	(0.477)
Age in Round 3	0.172***	0.167***
	(0.066)	(0.046)
Height-for-age at age 8 years	6.284***	4.742***
	(0.267)	(0.204)
BMI at 8 years	-0.268	-0.178
	(0.178)	(0.139)
Ethnic minority	-0.961	-0.545
	(0.868)	(0.738)
If first child of mother	1.396***	-0.203
	(0.481)	(0.364)
Study time, Round 3	0.098	0.042
	(0.140)	(0.105)
Work time, Round 3	0.091	-0.021
	(0.149)	(0.122)
Leisure time, Round 3	0.199	0.015
	(0.167)	(0.135)
Mother height	-0.008	0.009
	(0.008)	(0.010)
Mother completed lower secondary education (LSE)	0.447	-0.487
	(0.618)	(0.448)
Father completed LSE	1.110*	-0.558
	(0.582)	(0.472)
Wealth index Round 1 (normalised)	0.121	0.111
	(0.382)	(0.285)
Urban	-1.158	-0.633
	(0.817)	(0.659)
Northern Uplands	-0.806	0.374
	(0.840)	(0.611)
Red River Delta	-0.821	0.161
	(0.810)	(0.602)
Mekong Delta	-1.946**	-0.182
	(0.820)	(0.607)
Number of observations	423	437
R-squared	0.67	0.60

Notes: The standard errors are in parentheses, underneath the estimated coefficients;
*** p<0.01, ** p<0.05, * p<0.1

Table A4. *OLS estimations for the effect of growth velocity in two periods on cognitive and non-cognitive skills*

	Maths R3	PPVT R3	Non-cognitive
Growth velocity in Period 1	0.084**	0.090***	0.027
	(0.035)	(0.033)	(0.020)
Growth velocity in Period 2	0.031	0.018	-0.010
	(0.020)	(0.019)	(0.011)
Maths score R2, normalised	0.341***	0.075*	-0.034
	(0.041)	(0.039)	(0.023)
PPVT score R2, normalised	0.114***	0.340***	0.058**
	(0.042)	(0.040)	(0.024)
Non-cognitive index R2	0.206***	-0.027	0.129***
	(0.063)	(0.060)	(0.036)
Male	-0.164**	0.047	0.063
	(0.079)	(0.075)	(0.046)
Age (months), Round 3	0.001	-0.002	0.002
	(0.008)	(0.007)	(0.004)
Height-for-age at age 8 years	0.073**	0.069**	-0.029
	(0.033)	(0.031)	(0.019)
BMI at age 8 years	0.013	-0.001	0.006
	(0.021)	(0.020)	(0.012)
Ethnic minority	0.201*	-0.429***	-0.159**
	(0.114)	(0.108)	(0.066)
If first child of mother	-0.021	-0.026	-0.004
	(0.056)	(0.053)	(0.032)
Study time Round 3	0.053***	0.030*	0.034***
	(0.017)	(0.016)	(0.010)
Work time Round 3	-0.008	-0.023	-0.002
	(0.019)	(0.018)	(0.011)
Leisure time Round 3	-0.012	0.017	0.018
	(0.020)	(0.019)	(0.012)
Mother completed Lower Secondary Education (LSE)	0.160**	-0.104	0.008
	(0.069)	(0.065)	(0.040)
Father completed LSE	-0.040	0.023	-0.030
	(0.070)	(0.067)	(0.040)
Wealth index Round 1 (normalized)	0.093**	0.104**	0.047*
	(0.045)	(0.042)	(0.026)
Urban	0.151	0.082	-0.069
	(0.099)	(0.094)	(0.057)
Northern Uplands	-0.033	0.096	0.241***
	(0.098)	(0.092)	(0.056)
Red River Delta	-0.056	0.067	-0.033
	(0.093)	(0.088)	(0.053)
Mekong Delta	0.232**	-0.134	0.161***
	(0.095)	(0.090)	(0.055)
Number of observations	790	790	790
R-squared	0.45	0.43	0.16

Notes: The standard errors are in parentheses, underneath the estimated coefficients;
*** p<0.01, ** p<0.05, * p<0.1

Table A5. *OLS estimations for the effect of growth velocity in Period 2 on test scores and non-cognitive skills*

	Maths R3	PPVT R3	Non-cognitive
Growth velocity in Period 2	0.022	0.015	-0.013
	(0.019)	(0.018)	(0.011)
Maths score Round 2, normalised	0.340***	0.076**	-0.032
	(0.041)	(0.039)	(0.023)
PPVT score Round 2, normalised	0.111***	0.338***	0.054**
	(0.042)	(0.039)	(0.024)
Non-cognitive index Round 2	0.213***	-0.028	0.124***
	(0.063)	(0.060)	(0.036)
Male	-0.158**	0.024	0.054
	(0.078)	(0.074)	(0.045)
Age in months, Round 3	-0.005	-0.006	0.003
	(0.008)	(0.007)	(0.004)
Height-for-age at the start of Period 2	0.015***	0.014***	-0.002
	(0.005)	(0.004)	(0.003)
BMI at the start of Period 2	-0.011	0.006	0.013
	(0.014)	(0.014)	(0.008)
Ethnic minority	0.217*	-0.439***	-0.168**
	(0.114)	(0.108)	(0.065)
If first child of mother	-0.020	-0.024	-0.000
	(0.056)	(0.053)	(0.032)
Study time, Round 3	0.053***	0.031*	0.035***
	(0.017)	(0.016)	(0.010)
Work time, Round 3	-0.009	-0.023	-0.002
	(0.019)	(0.018)	(0.011)
Leisure time, Round 3	-0.012	0.017	0.019*
	(0.020)	(0.019)	(0.012)
Mother completed lower secondary education (LSE)	0.160**	-0.105	0.005
	(0.069)	(0.065)	(0.040)
Father completed LSE	-0.045	0.024	-0.030
	(0.070)	(0.067)	(0.040)
Wealth index, Round 1 (normalised)	0.097**	0.101**	0.044*
	(0.045)	(0.042)	(0.026)
Urban	0.166*	0.067	-0.085
	(0.099)	(0.094)	(0.057)
Northern Uplands	-0.024	0.096	0.239***
	(0.098)	(0.092)	(0.056)
Red River Delta	-0.060	0.055	-0.044
	(0.092)	(0.088)	(0.053)
Mekong Delta	0.240**	-0.145	0.141**
	(0.095)	(0.090)	(0.055)
Number of observations	790	790	790
R-squared	0.45	0.43	0.16

Notes: The standard errors are in parentheses, underneath the estimated coefficients;
*** p<0.01, ** p<0.05, * p<0.1

Table A6. *Determinants of early puberty, by gender*

	Boys	Girls
Height-for-age at 8 years	0.020	0.083***
	(0.021)	(0.021)
BMI at age 8 years	0.033**	0.055***
	(0.014)	(0.014)
Ethnic minority	0.005	0.075
	(0.069)	(0.075)
If first child of mother	0.012	0.044
	(0.038)	(0.037)
Mother completed lower secondary education (LSE)	-0.011	0.077*
	(0.049)	(0.045)
Father completed LSE	-0.022	0.042
	(0.046)	(0.048)
Wealth index, Round 1 (normalised)	0.033	0.044
	(0.030)	(0.029)
Urban	0.062	0.175***
	(0.065)	(0.066)
Northern Uplands	-0.213***	-0.091
	(0.065)	(0.062)
Red River Delta	-0.238***	-0.099
	(0.062)	(0.061)
Mekong Delta	-0.148**	0.097
	(0.064)	(0.061)
Number of observations	423	437
R-squared	0.14	0.25

Note: The standard errors are in parentheses, underneath the estimated coefficients;
*** p<0.01, ** p<0.05, * p<0.1

Growth in Middle Childhood and Early Adolescence, and its Association with Cognitive and Non-cognitive Skills at the Age of 15 Years

This paper uses longitudinal data gathered at the ages of 8, 12 and 15 years for nearly 1,000 children born in 1994–95 in Vietnam to investigate their growth between survey rounds and the links between the growth velocities and children's achievement in certain skills. We find that gender and the timing of puberty are the most important determinants of growth velocities. The growth velocities in the periods from 8 to 12 years and from 8 to 15 years of age are statistically significantly associated with cognitive achievement, but not with psychosocial competency. As far as intervention recommendations are concerned, we find that height-for-age at age 8 years is important because the effect of this factor is consistently positive and statistically significant on the major outcomes at the age of 15 years, such as height and cognitive achievement.

Young Lives
An International Study of Childhood Poverty

About Young Lives

Young Lives is an international study of childhood poverty, involving 12,000 children in 4 countries over 15 years. It is led by a team in the Department of International Development at the University of Oxford in association with research and policy partners in the 4 study countries: Ethiopia, India, Peru and Vietnam.

Through researching different aspects of children's lives, we seek to improve policies and programmes for children.

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- *Instituto de Investigación Nutricional, Peru*
- *Centre for Analysis and Forecasting, Vietnamese Academy of Social Sciences, Vietnam*
- *General Statistics Office, Vietnam*
- *Oxford Department of International Development, University of Oxford, UK*

Contact:
Young Lives
Oxford Department of International Development,
University of Oxford,
3 Mansfield Road,
Oxford OX1 3TB, UK
Tel: +44 (0)1865 281751
Email: younglives@younglives.org.uk
Website: www.younglives.org.uk

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