Economics and Human Biology 16 (2015) 100–114

Contents lists available at ScienceDirect

Economics and Human Biology

journal homepage: http://www.elsevier.com/locate/ehb

Trends in physical stature across socioeconomic groups of Chilean boys, 1880–1997

Javier Núñez *, Graciela Pérez

Economics Department, University of Chile, Diagonal Paraguay 257, Santiago, Chile

A R T I C L E I N F O

Article history:
Received 20 October 2012
Received in revised form 27 December 2013
Accepted 28 December 2013
Available online 28 January 2014

JEL classification:
N36
O15
O54
I15

Keywords:
Secular trends
Stature
Height
Anthropometry
Chile

A B S T R A C T

This paper studies the trends in height-by-age across socioeconomic groups of Chilean boys aged 5–18 born between 1880 and 1997, by performing a meta-analysis of 38 studies reporting height-by-age published since 1898. We estimate the trends using quantile regressions and by analyzing detailed height data from five selected studies. Both methods yield an average decennial increase in height of 1–1.1 cm, and 0.9 and 1.2–1.3 cm for boys of upper and lower socioeconomic status (SES), respectively. SES differences in heights of 9–11 cm are observed up to the late 1940s. However, boys born after the 1930s exhibit substantial convergence in height between socioeconomic groups, driven by an increase in height of middle and lower SES boys of 1.5 and 1.4–2 cm per decade, respectively. As a result, SES differences in height decreased to 5 cm in 1990s. Since these changes occurred in a context of moderate economic growth and persistent income inequality, we argue that our findings are associated with the emergence and expansion of social policies in Chile since the 1940s, which delivered steady improvements in health, nutrition and living conditions.

1. Introduction

Empirical research in recent decades has provided abundant evidence of secular growth in human height and body size in many populations worldwide over the last few centuries, and on how this pattern has been brought about by economic and social development and improvements in health, nutrition and living conditions of the population. However, two relevant dimensions of these patterns of human development have received less attention in the research agenda: first, most of the historical evidence has been generated for developed countries (where data has often been more readily available) and less is still known about the longer-term trends in height and body size in the developing world, and their specific patterns and driving forces.[1] Secondly, there is also less understanding of the variations in secular growth in body size across socio-economic groups within populations in more distant decades, even in developed countries (Cardoso and Caninas, 2009). This paper addresses these issues by employing a compiled dataset for analyzing the patterns of secular growth in physical stature in boys across

* Corresponding author. Tel.: +56 2 9783794; fax: +56 2 9783413.
E-mail addresses: jnunez@fen.uchile.cl (J. Núñez), grperez@fen.uchile.cl (G. Pérez).

[1] However, in the last decade there has been substantial research on physical living standards in Latin America in the past. See for example the research of López-Alonso and Porras (2003) on Mexico in late XIX and XX centuries, Salvatore (2004, 2009a, 2009b) on XX century Argentina, Frank (2006) on XIX century Río de Janeiro, Meisel and Vega (2007) on XX century Colombia, Challú (2009) on México in the XVIII and XIX centuries, Baten et al. (2009) on Argentina, Brazil and Perú in XIX and XX centuries and Grajales-Porras and López-Alonso (2011) who analyze the case of XVIII century Mexico.

1570-677X/$ – see front matter
http://dx.doi.org/10.1016/j.ehb.2013.12.008

socioeconomic groups in Chile since the end of the XIX century. We discuss this evidence in the context of the evolution of economic growth, economic inequality and the emergence and development of social policy and public health in Chile since the middle of the XX century.

In order to address these issues, we perform a meta-analysis of a height-by-age dataset constructed from 38 studies published by health professionals between 1899 and 2003, which report individual height data or height-by-age sample means of boys aged 5–18 of different socioeconomic status (SES). This age group was chosen at is offers more systematic coverage of boys' height measurements from a variety of sources, including primary and secondary schools, orphanages and residential institutions, armed forces and studies of the living conditions of working children, among other sources. From these 38 studies, a dataset was constructed that contains 447 sample means of height-by-age of boys aged 5–18, born between 1880 and 1997 and belonging to different socioeconomic strata throughout time.

In order to avoid the effects of potential socioeconomic biases in the data, this paper examines the trends in height-by-age across socioeconomic groups by means of two alternative methods, whose evidence we discuss in comparative perspective. The first method yields estimates of trends from six specific samples of the dataset coming from five studies, selected for having a detailed and well-defined socioeconomic description of its subjects from which upper and lower SES could be adequately imputed in view of contextual historical information. The second method performs quantile regressions on the complete height-by-age dataset of 447 observations to estimate trends in height at different quantiles of the conditional distribution of height. Since the samples come from a diverse range of socioeconomic niches of the population over time, we expect the selected quantiles to be associated with different socioeconomic strata in view of the abundant evidence that in a country with health and nutritional inequalities (like Chile in the XX century) the cross-section distribution of height is associated with SES. More specifically, we run quantile regressions to estimate the decennial growth in height for quantiles 20, 50 and 80 of the conditional distribution of height in the samples, which we expect to be associated with lower, middle and upper SES, respectively. Finally, we compare the results of the two methods outlined above to draw conclusions about the trends in height of boys across socioeconomic groups.

This paper is organized as follows: Section 2 describes the two methods outlined above and the data employed in each case. Section 3 reports the results of both methods. Section 4 discusses the evidence in the context of the trends in economic growth, economic inequality, social policies, healthcare and nutrition in Chile since the 1900s, and Section 5 concludes.

2. Methods and data

Appendix 1 provides a description of the 38 studies employed in this article, and their corresponding references. Given that socioeconomic selectivity in the samples was a relevant concern, these studies were gathered with the aim of attempting the highest possible coverage of different socioeconomic and regional niches of the population over time, instead of following a systematic search based on pre-determined procedures that could introduce biases in the search, or leave some studies undetected. Although the search was not originally restricted to a specific age group, upon examination of the studies we decided to focus our analysis on the 5–18 age group because it achieved a higher density of studies and more diversity of sources and socioeconomic niches over time, including primary and secondary school children, orphans, soldiers and working children, among others. As shown in Appendix 1, the 38 studies jointly contain information of height-by-age derived from height measurements of about 70 thousand boys and 48 thousand girls from different socioeconomic backgrounds and historical times born since 1880. This paper focuses on the study of trends in height among boys due to the better coverage of the male samples both across socioeconomic strata and also throughout time: as Appendix 1 indicates, the samples of girls go back only to 1929 and a reduced frequency and socioeconomic diversity (especially a lack of upper-class girls) and a small presence of older girls is observed in the girls' samples up to the 1950s. As shown in Appendix 1, most samples in the studies come from urban areas (mostly from Chile's capital city Santiago) although rural population is included in some studies. The samples come from a variety of socioeconomic strata of the population throughout time, and most of them come from narrowly-defined socioeconomic niches. However, there is a lower density of studies and data before the 1930s, and those studies seem to under-represent lower socioeconomic groups, for example poor "street boys" (Salazar and Pinto, 2002) that were often marginalized from schools and other institutions where most of the samples in this period come from. Since the 1930s there is a higher frequency of studies over time, with a wider coverage of different socioeconomic segments and territories. For these reasons, we analyze the data for all cohorts born between 1880 and 1997, as well as for the cohorts born since 1930. Boys from the poorest socioeconomic segments are less likely to be underrepresented in the later samples, as these studies often perform explicit socioeconomic sampling procedures (such as Ivanovic et al. (1991)), and also because near-universal primary school coverage was achieved in the early 1970s. This suggests that the secular trends in height of the lower socioeconomic group estimated by quintile regressions may be underestimated, as well as the degree of height convergence between upper and lower socioeconomic groups over time.[2] Note that a few studies contain height-by-age for a mixed socioeconomic population. Most of these studies report heights for separate socioeconomic populations, in which case they were divided into separate samples in order to have more socioeconomic heterogeneity

[2] However, the samples from Mesa (1948) used in the selected samples approach may provide a better estimate of growth in the poorest socioeconomic groups as it represents orphans and working-class boys from a poor district in Santiago.

Table 1
Selected samples of upper and lower SES boys.

Study	SES	Year	Sample Description	Place	Ages
Moraga del Hoyo (1899)	Lower	1898	Working-class boys, seamen/seafaring boys, stable boys, teenage infantry, over-age/repeat students in public elementary education	Santiago & Valparaíso	11–18
Matus Zañartu (1911)	Upper	1907	Secondary students at *INBA*, a prestigious public boarding school for students from upper and upper-middle-class families from Santiago and other cities	Santiago & other cities	10–18
Mesa (1948)	Lower	1948	Working-class boys from the poor *Quinta Normal* borough in Santiago, and from *Ciudad del Niño*, a residential institution for orphans and neglected children	Santiago	6–16
Royo (1948)	Upper	1948	Secondary *Humanidades* students from privileged private and public schools (57%) and affluent private and public primary schools participating in *Servicio Médico Escolar*	Santiago	6–18
Ivanovic et al. (1991)	Upper & Lower	1990	Representative sample of students from the Metropolitan Region, derived from an explicit socioeconomic sampling procedure using a modified Graffar scale	Metropolitan Region	6–18

in the dataset. In other cases, separate socioeconomic samples could be defined from the available individual data. From these studies, a final dataset was constructed, which contains 447 *sample means* of height-by-age of boys aged 5–18, born between 1880 and 1997, where the samples are drawn from different socioeconomic strata throughout time. The studies contain little information as to the specific ethnic background of the subjects. However, it is estimated that only 25 per cent of the Chilean population are descended mainly from Europeans (mostly Spanish), while the majority (70 per cent) are *Mestizos* (mixed Spanish and Amerindian background) and only 5 percent are of predominantly Amerindian ethnic background, most of whom have historically lived in rural and small urban areas in southern and northern Chile (Collier et al., 1992). Since the *Mestizaje* began with the arrival of the Spanish in the mid 1500s, most of this process occurred well before the period covered by this study. On the other hand, there was some immigration in Chile in the last two centuries, but it has been minimal relative to the population and well below the levels of other countries in the region such as Argentina, Uruguay and Brazil (Salazar and Pinto, 1999). Often immigrants arrived from neighboring South American countries where the ethnic and genetic background is similar, or from Spain, a common ancestor of most Chileans. Also, part of the non-Spanish European immigration to Chile occurred during the XIX century before the time frame of this study (Salazar and Pinto, 1999). Consequently, the subjects included in the studies are expected to be mostly of *Mestizo* and Spanish ancestry throughout the 120-year span of this study, with a small and stable proportion of Amerindians and descendants of non-Spanish Europeans. Hence, the evolution of height would be mostly a consequence of changes in health, nutrition and living conditions during this period rather than changes in the genetic pool of the Chilean population.[3]

2.1. Estimating trends in height across socioeconomic groups from selected samples

This method estimates the trend in height using data from six height-by-age samples of upper and lower SES boys selected from five of the 38 collected studies. The six selected samples and the five studies from which they were obtained are shown in Table 1, and are described in detail in Appendix 2. As seen therein, these samples include boys in the 6–18 age range. The height-by-age samples comprise 67 of the total of 447 height-by-age sample means for boys obtained from the studies listed in Appendix 1. These samples were selected from the database for the following reasons: (i) they provide height-by-age in three key periods: the beginning, middle and end of the XX century, (ii) the studies provide a detailed socioeconomic description of the corresponding population, from which an upper or lower SES could be imputed with reasonable confidence considering historical contextual information, (iii) they report sample size and standard deviations of height-by-age, which are required in order to perform statistical inference across samples, and (iv) they provide height-by-age for a substantial age range within ages 6–18, thus providing a common support of age groups across samples.

From these six samples, differences in height-by-age between boys of upper and lower SES were obtained for 1991, 1948 and c. 1900 (by comparing the 1989 and 1907 samples), and trends in height-by-age during these periods were calculated separately for boys of upper and lower SES.

2.2. Estimating secular trends using quantile regressions

The second method performs quantile regressions on the complete dataset in order to identify secular growth in Chilean boys across socioeconomic groups. Quantile regressions have been widely used in a variety of fields to estimate models of conditional *quantile* functions (as opposed to the conditional *mean* as in OLS). Quantile regressions are useful for studying the heterogeneous response of a dependent variable (like height in this paper)

[3] Moreover, there is no conclusive evidence as to the effect of European ancestry on height in recent decades in Chile, after controlling for socioeconomic status. See Ivanovic et al. (1991) for references and a brief discussion of the evidence.

Table 2
Height-by-age sample means and Height differences between Upper and Lower Socio-economic status (SES) samples, c. 1900, 1948 & 1991 (cm).

Ages	Upper SES samples			Lower SES samples			Height difference, Upper vs. Lower SES		
	1907	1948	1991	1898	1948	1991	c. 1900	1948	1991
	(1)	(2)	(3)	(4)	(5)	(6)	(1-4)	(2-5)	(3–6)
6		118.2	118.9		104.7	116.2		13.5***	2.7***
7		123.6	123.4		112.5	121.5		11.1***	1.9*
8		127.2	124.2		117.4	124.3		9.8***	-0.1
9		131.4	136.9		122.5	130.9		8.9***	6.0***
10	137.0	135.9	138.5		125.2	135.2		10.7***	3.3***
11	138.0	140.6	146.0	132.4	132.5	140.6	5.6**	8.1***	5.4***
12	142.3	145.3	152.2	131.0	140.6	144.6	11.3***	4.7***	7.6***
13	150.0	152.5	159.4	140.9	142.8	151.1	9.1***	9.7***	8.3***
14	154.0	158.6	164.4	145.2	146.8	157.0	8.8***	11.8***	7.4***
15	161.1	164.3	169.5	149.3	151.6	162.8	11.9***	12.7***	6.7***
16	165.0	168.1	170.1	153.6	152.5	162.1	11.4**	15.6***	8.0**
17	166.1	169.5	173.2	160.8		170.1	5.3**		3.1*
18	167.4	170.4	176.9	157.5		171.5	9.9***		5.4*
Obs.	821	3706	532	73	401	871			
Average							9.2***	10.6***	5.1***
St. Deviation							0.9	0.9	0.7

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

to changes in independent variables (like the year of birth) at different quantiles (including the median) of the conditional distribution of the dependent variable (height).[4] As outlined earlier, this method rests on the assumption well supported by worldwide empirical evidence that at one moment in time, the more affluent groups in countries with inequalities in health and nutrition (like developing countries and developed countries in the past) exhibit significantly higher height-by-age than the lower socioeconomic groups.[5] These socioeconomic height differences would decrease if health and nutrition eventually became more homogeneous across socioeconomic groups. However, provided that samples are drawn from different socioeconomic populations over time and that health and nutrition inequalities persist to some degree (as in Chile throughout the XX century), the centile of the height-by-age mean of a specific sample in the conditional distribution of height at a given moment in time would be partly associated with the prevalent socioeconomic status and the living conditions of the individuals in that sample.[6] This is well supported by the evidence of substantial socioeconomic height differences in Chile throughout the 120-year period that we report in Table 2.[7] Thus, estimating a quantile regression on sample means of height-by-age drawn from different socioeconomic segments would provide an indication of trends in height across groups exposed to different nutrition and health conditions at different moments in time, which we argue are likely to be associated with SES. More formally, we estimate the following specification by OLS, as well as by quantile regressions for quantiles 20, 50 and 80 of the conditional distribution of height;

$$h_i = \alpha + \beta y_i + \gamma_1 a_i + \gamma_2 a_i^2 + \gamma_3 a_i^3 + \gamma_4 a_i^4 + \varepsilon_i$$

where h_i is the average height in cm of individuals in sample i, α is a constant term, y_i corresponds to the cohort or common year of birth of all individuals in sample i and a_i is the age of all individuals in sample i at the year of their measurement. β measures the effect on height of the year of birth of individuals in sample i, or in other words, the marginal effect on height (in cm) of being born one year later and (presumably) benefitting from an improved environment and better living conditions.[8] Likewise, 10β would yield the *decennial* secular growth in cm. Terms γ_1, γ_2, γ_3 and γ_4 are the coefficients of a polynomial function of age that captures the non-linear pattern of growth during childhood and puberty, as commonly used in the literature to describe human growth.[9] A fourth-degree polynomial of age provides a good fit for growth in ages 5–18, and is consistent with the asymmetric growth rate observed prior

[4] See for example Greene (2011), Koenker (2005) and Cade and Noon (2003) for an explanation and applications of quantile regressions.

[5] In Section 4, we discuss some evidence of socioeconomic height differences for various developed countries in the past.

[6] We did not assign a SES to every sample because the information available was often limited and not comparable across studies over time.

[7] There is no conclusive evidence of the effect of ancestry on height *conditional on socioeconomic status*. Accordingly, SES remains a key determinant of height in Chile even in recent decades (see Ivanovic et al. (1991, p. 1330) for a brief survey of the evidence).

[8] Note that this specification assumes that the year of birth has a constant effect on height in ages 6–18. This has been assumed implicitly in the literature and is coherent with the evidence that most stunted growth often occurs in the first years of life and persists in later ages (Karlberg, 1998, p. 112; Cole, 2003). However, we also perform regressions where year of birth has a differentiated effect by age.

[9] See for example Hauspie (1998, pp. 114–115) for an explanation of high-order polynomials used in the human growth literature, and Hansen et al. (2003) for evidence about the good performance of non-linear Ordinary Least Squares to describe longitudinal human growth.

Table 3
Decennial Secular Growth (cm), boys aged 6–18, Upper vs. Lower Socioeconomic status (SES).

	Upper SES			Lower SES			Secular growth differences		
	1907–1948 (1)	1948–1991 (2)	1907–1991 (3)	1899–1948 (4)	1948–1991 (5)	1899–1991 (6)	(4-1)	(5-2)	(6-3)
6		0.2			2.6***				
7		0.0			2.0***				
8		−0.7*			1.5***				
9		1.3**			1.9***				
10	−0.3	0.6**	0.2		2.2***				
11	0.7*	1.3**	1.0**	0.0	1.8***	0.9***			
12	0.8**	1.6**	1.2**	1.9**	0.9***	1.5***			
13	0.6*	1.6**	1.1**	0.4	1.8***	1.1***			
14	1.1**	1.4**	1.3**	0.3	2.3***	1.3***			
15	0.8**	1.2**	1.0**	0.5	2.5***	1.5***			
16	0.8**	0.5*	0.6*	−0.2	2.1***	0.9*			
17	0.8**	0.9**	0.9**			1.0***			
18	0.7**	1.5**	1.1**			1.5***			
Average	0.7	0.9	0.9	0.5	2.0	1.2	−0.2	1.1 ***	0.3*
St deviation	0.39	0.72	0.34	0.74	0.47	0.27			

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

to and after the adolescent growth spurt. Finally, ε_i denotes the error term of the mean height of sample i, which can be interpreted as defined by the prevalent socioeconomic (or health and nutrition) status of the individuals in sample i and their prevalent genetic background.[10]

The specification above assumes that the cohort variable and the polynomial of age have separable effects on height. However, adolescent growth spurts are expected to occur at a later age when individuals experience delayed maturation due to adverse nutrition and health conditions.[11] To address this issue, we examine the growth patterns and adolescent growth spurts over time in Chile, and also estimate alternative regression models that include birth cohort and age interactions.

3. Results

3.1. Evidence of secular trends from the selected samples

Table 2 reports height-by-age means of the six selected samples described in Table 1, as well as the height differences between upper and lower SES boys in the samples of c. 1900, 1948 and 1991, which correspond to cohorts born in the 1880s and 1890s, between 1930–1942 and 1973–1985, respectively.

Table 2 provides evidence of differences in height-by-age associated with SES in the three cross-sectional periods, with all socioeconomic differences being statistically significant c. 1900 and in 1948, and all except one sample in 1991. Table 2 also indicates that the differences in height-by-age between upper and lower SES boys were relatively large and similar c. 1900 and in the late 1940s (about 9–11 cm). This suggests no convergence of height between the upper and lower socioeconomic groups during this period. These results suggest substantial and persistent differences in health, nutrition and living conditions between upper and lower socioeconomic groups from (at least) the 1880s up to the 1940s.

However, the socioeconomic difference in height was significantly lower in 1991 (about 5 cm on average), indicating a substantial convergence in height between upper and lower SES boys since the middle of the XX century, and suggesting a narrowing difference in health, nutrition and living conditions between these groups during this period.

Table 3 reports the decennial growth in height of upper and lower SES boys aged 6–18, according to the height-by-age sample means in Table 2. Table 3 indicates that boys of both upper and lower SES experienced significant growth in height during the XX century. However, the magnitude of the trend in height for both socioeconomic groups is different: the average decennial growth of upper and lower socioeconomic groups were 0.9 and 1.2 cm, respectively.[12]

Table 3 also suggests that growth and convergence in heights between socioeconomic groups has been accentuated since the mid XX century: while upper-class boys grew taller at a steady rate during the XX century, boys from lower SES show moderate secular growth up to the 1948 samples (0.5 cm per decade), but substantial growth between the 1948 and 1991 samples (2 cm per decade). As

[10] Effects *common* across SES (like some epidemics, universal vaccination, pollution) would not explain differences in mean height across contemporaneous samples. Also, since we use sample means (not individual data), only *between-samples* genetic differences are expected to explain differences in mean height across samples, not *within-sample* individual genetic variation.

[11] See for example Eveleth and Tanner (1990), Johnson (1998) and Cole (2003).

[12] Statistically significant at 10 per cent. The decennial growth between c.1900 and 1991 is computed for boys ages 10–18 for the upper SES and 11–18 for the lower SES, which may have an effect on the averages. However, since the age ranges are similar, the evidence reported still suggests convergence in heights between boys of upper and lower socioeconomic groups.

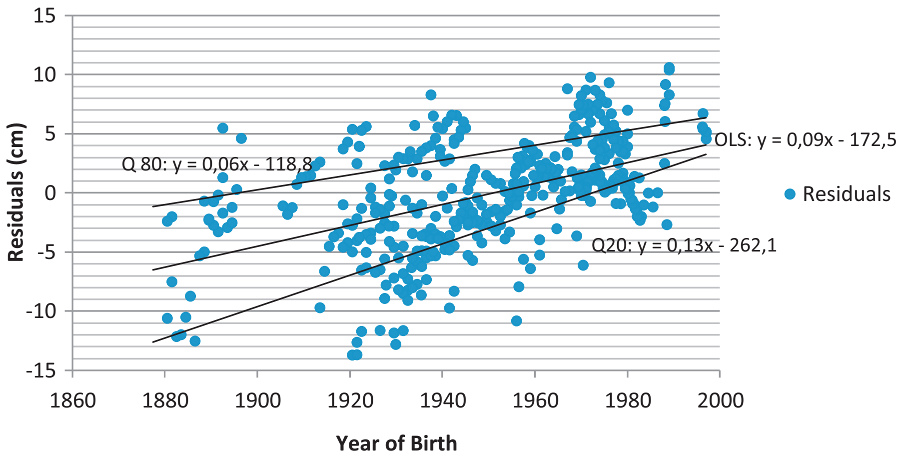

Fig. 1. Residuals of age-polynomial regression and trends: OLS, quantiles 20 and 80.

a result, the difference in growth between the lower and upper SES between 1948 and 1997 is 1.1 cm per decade.

3.2. Trends in height from OLS and quantile regressions

In this section, we further analyze these patterns of secular growth by estimating OLS and quantile regressions on the complete dataset of 447 height-by-age sample means described in Section 2. In order to illustrate the data employed, Fig. 1 reports the residuals of a regression of the height-by-age data on a four-degree age polynomial, as in the equation presented in Section 2.2 but where the trend term has been omitted. Fig. 1 indicates that: (i) residuals increase with the year of birth, suggesting that the trend term is a relevant omitted variable and (ii) the dispersion of residuals decreases with the year of birth, as suggested by the decreasing range of variation of residuals (especially after the 1940s) and the converging slopes of the trends fitted at quantiles 20 (Q20) and 80 (Q80) of the conditional distribution of height (by means of quantile regressions).

Appendix 3 reports OLS and quantile regressions for quantiles 20, 50 and 80 of the conditional distribution of height with year of birth included as a regressor. These regressions show a substantial goodness-of-fit, with the coefficients of the fourth-degree age polynomial being statistically significant across all specifications, and with values consistent with the pattern of growth in boys aged 5–18.[13]

Table 4 shows the estimated coefficients of the year of birth for all regressions reported in Appendix 3. The evidence indicates an average trend of boys born between 1880 and 1997 (estimated by OLS) of about 1.1 cm per decade, similar to the 0.94 cm for the median (quantile 50). However, Table 4 also suggests a substantial disparity in the growth in height in the same cohorts across socioeconomic strata: the decennial growth for quantiles 20 and 80 (expected to be associated to lower and upper socio-economic strata, respectively) are 1.32 and 0.87 cm, the difference of −0.45 cm being statistically significant at 5 per cent confidence. These estimates of growth are similar to those in Table 3 based on selected samples, namely a decennial growth of 1.2 and 0.9 cm between c. 1900 and 1991 for boys of quantile 20 and 80, respectively. This similarity of the estimates derived from both methods provides robust evidence of growth in height among Chilean boys born since 1880, and of convergence in height between upper and lower SES boys during this period.

Table 4 also reports a decennial growth of boys born between 1930 and 1997 of 1.4 and 1.5 cm for quantiles 20 and 50 (likely to be associated with lower and middle SES, respectively), higher than the 1.0 cm of quintile 80 (expected to be associated with upper SES). This estimate for quantile 80 is similar to the decennial growth of 0.9 cm of the upper socioeconomic groups between the samples of 1948 and 1991 reported in Table 3. The estimate for quantile 20 is lower than the 2 cm growth estimate from Table 3. One possible explanation for this difference is that the estimates from quantile regressions may be underestimated as the earlier samples may have underrepresented poor "street children", often not attending schools or other institutions where most of the early samples come from. Nevertheless, the evidence from Table 4 confirms an important convergence in heights of Chilean boys born since 1930 characterized by a relatively high secular growth of the lower and middle socioeconomic groups in the range of 1.4–1.5 cm per decade.

As discussed in Section 2, the results in Table 4 are derived assuming that the pattern of growth is unaffected

Table 4
Estimates of annual growth in height without birth cohort and age interactive effects.

Birth cohorts	OLS	Q20	Q50	Q80
1880–1997	0.107***	0.132***	0.094***	0.087***
1930–1997	0.123***	0.142***	0.152***	0.101***

*** Statistically significant at 1 per cent.

[13] Differentiating the coefficients of the fitted fourth-degree polynomial of specifications in Appendix 3 with respect to age yields maximum growth rate at about age 13, consistent with the evidence of growth spurts in boys (see for example Bogin (1998)) and Fig. 2.

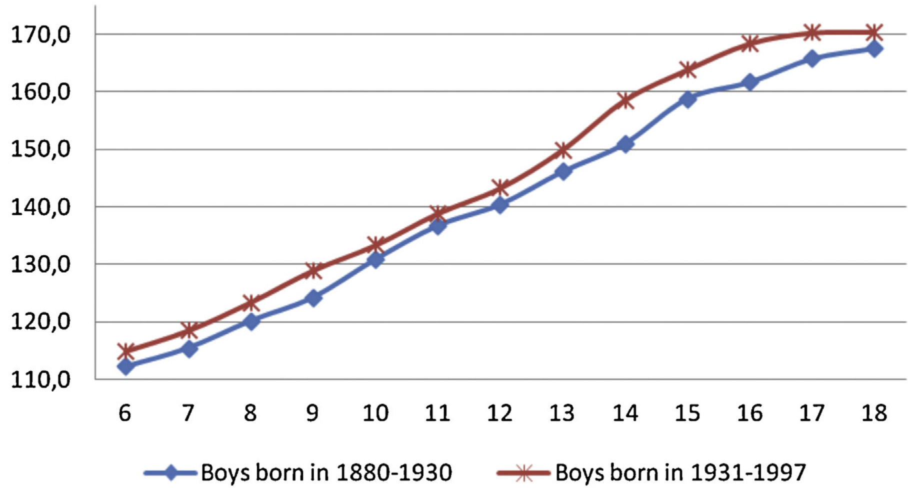

Fig. 2. Height-by-age (cm) of Chilean boys, cohorts 1880–1930 vs. 1931–1997.

by secular growth, although growth spurts are expected to move forward as a result of earlier maturation associated with improved environmental conditions.[14] To analyze this, Fig. 2 reports the height-by-age of Chilean boys of all SES born in 1880–1930 and in 1931–1997.

Fig. 2 shows that boys of all ages born after 1930 are taller than their counterparts born up to 1930, as expected. However, the adolescent growth spurt differs between both groups: boys born after 1930 accelerate their growth at 12 years of age and achieve maximum annual growth between 13 and 14, after which annual growth slows down and eventually stops at 17–18 years of age. On the other hand, boys born up to 1930 achieve their maximum annual growth between ages 14 and 15 (8 cm) suggesting a delayed maturation compared to boys born after 1930. In fact, they continue to grow fairly steadily up to 18 years of age and possibly thereafter. Thus, the height difference between both populations increases from about 3–4 cm up to age 12 to about 9 cm at age 14, and then decreases to about 3–4 cm at ages 17–18.[15] Fig. 2 provides further evidence of an improvement in health and nutrition conditions throughout the 120-year period in Chile. But it also confirms the appropriateness of estimating secular trends by estimating regression specifications that include birth cohort and age interactions, as shown in Appendix 4. The specifications of the cohort and age interactions were allowed to vary across quintiles 20, 50 and 80 because the adolescent growth spurt is also expected to differ across socioeconomic groups at one moment in time due to differences in living conditions. The specifications were selected by imposing a statistical significance threshold of at least at 10 per cent.[16] As Appendix 4 shows, all regressions have significant age-cohort interactive

Table 5
Decennial growth (cm) by age groups, estimated with age & cohort interactive effects from Appendix4, cohorts 1880–1997.

Ages	OLS	Quantile regressions		
		Q20	Q50	Q80
6–8	0.9	0.7	1.0	0.9
9–10	0.9	1.2	1.1	1.1
11–12	1.0	1.4	1.2	1.0
13–14	1.2	1.7	1.4	0.9
15–16	1.4	1.7	1.5	0.9
17–18	1.0	1.1	0.9	0.8
Average of ages 6–18	1.1	1.3	1.2	0.9

coefficients, consistent with a changing pattern of growth through time. Note also that the estimated coefficients are different between quantiles 20, 50 and 80, suggesting that the pattern of growth also differs across socioeconomic groups.

Table 5 reports the decennial growth by age groups estimated from the respective coefficients in Appendix 4. The average growth for ages 6–18 is similar to the respective figures reported in Table 4 (estimated without cohort and age interactions). However, Table 5 indicates that secular growth is larger for ages 13–16 for quantiles 20 and 50. This is consistent with the previous finding of adolescent growth spurts moving forward as a result of improving living conditions over time, especially in boys of lower quintiles of the conditional distribution of height (likely to be associated with lower and middle SES) who would have experienced substantial delay in maturation. This is in turn consistent with international evidence showing that height secular trends in boys exhibit a peak at about age 15 (Cole, 2003, p. 163).

4. Discussion

This article has provided evidence of various salient patterns of secular growth in height of Chilean boys across socioeconomic groups since the end of the XIX century. The

[14] See for example Eveleth and Tanner (1990), Johnson (1998) and Cole (2003).

[15] Note that these figures are smaller than total secular growth over the 120-year period reported earlier, as expected.

[16] This was performed using STATA's backward *stepwise* model selection procedure, starting from the full model.

two methods employed in this paper provided similar evidence about these salient patters, which we summarize and discuss below.

4.1. Socioeconomic height differences in boys, 1898–1991

A persistent difference in height-by-age of about 9–11 cm between boys of upper and lower SES is observed between c. 1900 and 1948. This difference is larger than socioeconomic height differences around 1900 reported in the literature, for example, the 7 cm difference between upper and lower SES boys in Lisbon in 1910 (Cardoso and Caninas, 2009), the 1.2 cm height difference between middle-class and working-class cadets in the United States in the second half of the XIX century (Komlos, 1987), and the 2–3 cm height difference around 1900 in Sweden between sons of unskilled laborers vs. managers and professionals (Ulijaszek, 1998). The reported height difference is similar to the 10 cm difference in height between boys of upper-class and working-class background around 1900 in Britain (Ulijaszek et al., 1998, p. 402), which is however the country that had the largest socioeconomic height differences in the XIX century (Komlos, 1987). This suggests a substantial degree of social and economic inequality around 1900 in Chile and is consistent with the evidence of widespread poverty in cities such as Santiago as a consequence of rural immigration during the second half of the XIX century that created severe housing, nutrition and sanitary problems well into the XX century.[17] This triggered an intense public debate in Chile between 1880 and 1920 about the dismal living conditions of the poor, and its stark contrast with the privileged situation of an affluent minority.[18] The resulting adverse living conditions are also visible in the evidence of widespread undernutrition and deficient diet of the poor,[19] and the high levels of infant mortality and low life expectancy around 1900 (see Appendix 5). The large socioeconomic differences in height are also coherent with the evidence of stagnant real wages in most regions and economic sectors in Chile between c.1900 and 1930,[20] considering that social policies were minimal up the 1940s[21] and therefore nutrition and health status would have been largely associated with real incomes.

However, the large socioeconomic differences in height are also coherent with the fairly high height-by-age exhibited by affluent Chilean boys at that time, similar to some of their contemporary European and North American counterparts: upper-class IMBA students in 1907 were taller than upper-middle class boys from Colégio Militar in Lisbon in 1910, and similar to Habsburg cadets in the late XIX century in Austria, although shorter than students from École Polytechnique in France and elite cadets in the United States and Britain in the second half of the XIX century, who were however among the tallest sub-populations in the western world around that time (Komlos, 1994, 2006).[22] The relatively tall height of Chilean upper-class boys c. 1900 (for a developing country) should not be surprising, given Chile's high GDP per capita for Latin American standards, not far from some European countries (see Appendix 5).

The substantial socioeconomic difference in height observed in the first half of the XX century narrowed to about 5 cm between 1948 and 1991, thus providing an indication of convergence in living conditions of boys of upper and lower SES born since approximately the 1930s, an issue that we discuss next.

4.2. Convergence in height across socioeconomic strata, 1880–1997

Both methods followed in this article provide similar evidence of growth in height across socioeconomic groups. The growth in height in boys aged 6–18 born between 1880 and 1997 is 1.1 cm per decade on average (estimated by OLS), and 0.94 cm for the median population (quantile 50). This is also consistent with the finding of adolescent growth spurts moving forward during the 120-year period, as physical maturation occurred earlier in the cohorts born after the 1930s. As a result, the average trend in height peaks at 1.4 cm around age 15. These growth estimates for the general population are close, but often somewhat lower than the decennial growth in height observed in boys from developed countries in similar periods, for example 1–1.2 cm in Madrid between 1896 and 1990, 1.5 cm in Lisbon in 1910–2000, 1.5 cm in Athens between 1928 and 2001 (Cardoso and Caninas, 2009), 2.5 cm in post-war Japan (Cole, 2003), 1.9 cm for 13-year old Czech boys since 1895 (Vignerová et al., 2006), 1 cm in Germany in 1975–1995 (Zellner et al., 2004) and 1.5–1.6 cm per decade reported by Eveleth and Tanner (1990) for boys in a number of developed countries between the 1880s and the 1980s. However, our results indicate substantial growth in height since the end of the XIX century, suggesting important improvements in nutrition and health in Chile during this period.

Nonetheless, the evidence also points to considerable heterogeneity in the degree in which different socio-economic groups benefited from these improvements: boys ages 6–18 in quantile 20 of the conditional distribution of height (expected to be associated with lower SES) born between 1880 and 1997 had a faster

[17] A detailed description of this process and its consequences on the living conditions of the poor in Santiago is found in Romero (1997).

[18] For references about this debate known as "*La Cuestión Social*" ("The Social Question"), see Grez (1997) and Collier and Sater (2004).

[19] There were important socioeconomic disparities in the diet in the first half of the XX century, and widespread undernutrition among poor families was caused by insufficient calorie and protein intake and a deficit in some vitamins (particularly vitamin A), and a diet dominated by wheat-based products with a seasonal intake of fruits and vegetables and substantial alcohol intake among adults. This deficient diet affected the growth of children from early ages, and up to the mid 1960s the effect of public feeding programs on children's diet was small and patchy. See Dragoni and Burnet (1938), Allende (1939), Santa María (1941), ICNND (1961), Monckeberg et al. (1967) and Solimano et al. (1972).

[20] See Matus (2009) for evidence and a discussion of related literature.

[21] See the evidence in Appendix 5 and the discussion below.

[22] See Komlos (1987, 2006, p. 313), and Cardoso and Caninas (2009).

decennial growth of about 1.2–1.3 cm, while their counterparts in quantile 80 (expected to be associated with higher SES) grew only about 0.9 cm per decade. These results suggest substantial convergence of height across socioeconomic groups during this period, a pattern that has been observed in the international evidence, but not as a general rule. For example, widening height class-differences were observed in the XVIII and XIX centuries in the United States and Europe during and after the industrial revolution (Komlos, 1990, 2008). Also, Cavelaars et al. (2000) report declining education-related height differences in ten Northern and Western European countries throughout the XX century, but coefficients are small and statistically insignificant. In the developing world, López-Alonso and Porras (2003) find widening height differences in XIX century Mexico and Subramanian et al. (2011) report widening SES height differences in late XX century in many of 54 middle and lower-income countries.[23]

4.3. Secular growth of lower and middle socioeconomic groups and height convergence since 1930

The results suggest substantial convergence in the height of boys born after the 1930s, which is characterized by a relatively high rate of secular growth in boys of quantiles 20 and 50 (associated with middle and lower SES) in the range of 1.5 and 1.4–2 cm, respectively, higher than the estimate of 0.9–1 cm for boys in quintile 80 (associated with upper SES). These estimates suggest a substantial degree of height convergence in this period driven by an important growth in height of the middle and lower SES boys compared to the international evidence on decennial trends in height reported earlier.[24]

We now discuss some possible driving forces of these findings, and for this purpose Appendix 5 reports selected economic and social indicators for Chile between 1900 and 1990. One possible explanation for the socioeconomic convergence in height in cohorts born after the 1930s – driven by a high secular growth of boys of lower and middle SES – may be a possible decline in economic inequality, as suggested in the literature.[25] This explanation, however, is not supported by the evidence for the case of Chilean boys. As Appendix 5 shows, available measures of income inequality for Greater Santiago since the 1950s reveal a high and stable income distribution since then, and no steady decline is in fact observed. Another hypothetical explanation is a possible pattern of economic growth increasing rapidly the real incomes of the lower socioeconomic groups since the 1930s. However, as Appendix 5 shows the per capita income growth in Chile since 1930 is moderate, with annualized rates in the range of 0.3–2.1 in the decades between 1930 and 1990, which are lower than the increase of GDP per capita in the United States, Western Europe and the major Latin American countries (until the 1990s). Although this moderate economic growth would have contributed to the improvement of the standards of living in Chile during this period, it is unlikely that it would have been the major driving force of the substantial improvement in living conditions described above. More specifically, the joint evidence of moderate growth of income per capita in Chile combined with high and persistent income inequality provides little support for an explanation based on the increase of the real incomes of the poor and middle class since the 1930s.

However, the evidence in Appendix 5 shows that physical living standards have in fact exhibited substantial improvement since the 1940s, as suggested by the considerable and steady decline in infant mortality – faster than the rest of the Latin American region at least since 1950 – and the rapid increase in life expectancy from dismal levels in the first decades of the XX century to levels similar to those of some developed countries toward the end of the century. This is also in line with the evidence that Chile experienced its demographic and epidemiological transitions from about 1960 onwards at a fairly fast pace (Szot Meza, 2003; Aguila and Muñoz, 1997), and the evidence of a substantial decrease in the age of menarche in girls between 1940 and 1970 (Rona, 1975). All this evidence is consistent with the findings of this paper, namely a substantial growth in physical stature of the population in general, but accentuated in the lower and middle socioeconomic groups born since the 1930s. We conjecture that in a context of moderate economic growth combined with high and persistent economic inequality, these improvements in living conditions were possible by the emergence of an incipient welfare state in Chile in the 1940s and its gradual development in subsequent decades, which is visible in the substantial and steady increase in public social expenditure since the 1940s and 1950s reported in Appendix 5. This indicates that even in the context of moderate economic growth described earlier, the rapid increase of social public expenditure as a fraction of GDP since the 1940s would have yielded a substantial and steady increase in the flow of resources devoted to social policies.[26] This made possible the implementation of a variety of landmark social and development policies in Chile that have been well-documented in the literature. These include the preventive medicine programs and workers' social protection programs developed in 1938,[27] which paved the way for the creation of the National Health Service (NHS) in 1952 (a pioneer achievement in the Latin American region). Since its creation, the NHS

[23] However, there is also substantial evidence of socioeconomic convergence in height. See for example Alter et al. (2004) on XIX century Belgium, Meisel and Vega (2007) on XX century Colombia, Li et al. (2004) and Kuh et al. (1991) on XX century Great Britain and Cernerud, Elfving (1995) on XX century Scandinavia and Arcaleni (2006) on height convergence between richer and poorer regions in Italy since 1930.

[24] These figures are however somewhat lower than other reported growth among boys, for example in Bielecki et al. (2012).

[25] See for example Cardoso and Caninas (2009).

[26] The evolution of the welfare state and social policies in Chile during the XX century are described in Hojman (2001) and Larrañaga (2010).

[27] Ley de Seguro Obrero y Medicina Preventiva, 1938. For a description, see for example Hojman (2001) and Larrañaga (2010).

increasingly implemented programs such as technical assistance of delivery, responsible parenthood and healthy child control, health visitors, vaccinations campaigns, complementary feeding (including milk for babies, schoolchildren, and pregnant and lactating women) and sanitary education, among others.[28] Also, since the 1950s there was a rapid expansion of primary schooling, which was also declared compulsory up to 8th grade in the mid 1960s. Primary schooling reached near-universal coverage in the early 1970s (early for Latin American standards), which was combined with substantial school aid and feeding programs initiated in the 1950s but implemented with more determination since 1965.[29] This generated a steady and reliable source of food for school children that possibly boosted the nutritional status of poor children at a critical age of their growth and development (including the growth-spurt in boys at about 13–14 years). Another relevant factor was the implementation of housing programs combined with substantial investment in urban infrastructure such as sewage and potable water networks in urban areas, which were experiencing substantial population growth paired with increasing industrialization since the 1940s.[30] These investments occurred increasingly since the 1950s, but with more sustained emphasis since the mid 1960s.[31] All of these policies created better nutrition and health conditions for an increasing proportion of the Chilean population, especially the poor in urban areas, in spite of moderate economic growth and persistent income inequality.[32]

5. Conclusions

This paper has followed two methods to study the trends in height-by-age across socioeconomic groups of Chilean boys aged 5–18 born between 1880 and 1997: quantile regressions and the analysis of detailed height data from selected studies. Both methods yield fairly convergent results, namely an average decennial increase in height of 1–1.1 cm, and 0.9 and 1.2–1.3 cm for boys of upper and lower SES, respectively. SES differences in heights of 9–11 cm are observed up to the late 1940s, suggesting large and persistent inequalities in living conditions throughout this period. However, boys born after the 1930s exhibit substantial convergence in height between socioeconomic groups, which is driven by an increase in height of middle and lower SES boys of 1.5 and 1.4–2 cm per decade, respectively. As a result, SES differences in height decreased to about 5 cm in the 1990s. We argue that since these changes occurred in a context of moderate economic growth and persistent income inequality, our findings are associated with the increase of public social expenditure (as a fraction of GDP) and the emergence and development of a variety of social policies in Chile since the 1940s, which delivered steady improvements in health, nutrition and living conditions, as corroborated by the related literature.

We conclude by pointing out that the evidence presented concerns the evolution of height of mostly urban boys, and therefore it may not adequately reflect the evolution of height of boys in rural areas. It is unclear how nutritional and health conditions may have differed between urban and rural areas in Chile through time. Thus, addressing the evolution of height and living conditions in urban and rural contexts in comparative perspective remains an interesting topic for future research. Also, the reported secular trends in height should not be extrapolated to the adult population. Although the results suggest an important increase in height of adults in the period, its magnitude is expected to be smaller as a result of the pattern of secular growth by age groups discussed above.

Acknowledgments

We are indebted to Joseph Ramos, Mario Matus, Vicente Neira, Luis Riveros, Ricardo Ffrench-Davis and Bernardita Escobar and the participants in CLADHE-II conference in Mexico City, February 3–5, 2010 for their comments and insights. We also thank the comments of the anonymous referees and editor Prof. J. Komlos. Javier Núñez is grateful to CILAS, University of California, San Diego, for the support provided during the drafting of this article. We also thank the assistance provided by Matías Núñez, and by Susana Silva and Rosario Macera in the earlier stages of this research.

[28] For a detailed history of the origins and development of the National Health Service, see Rosselot (1993). For a description and analysis of the National Milk Program, see Solimano (1972). Health visitors and other aspect of public health in Chile are described in Illanes (2010).

[29] School feeding programs for vulnerable primary school students started in the 1950s, evolving into the creation of The National Scholarships and School Aid Board, (Junta Nacional de Auxilio y Becas, (JUNAEB)) in 1964. For a brief history of JUNAEB, see http://www.junaeb.cl/prontus_junaeb/site/artic/20091013/pags/20091013154429.html.

[30] This industrialization was partly triggered by the international recession that hit Chile in 1930–31. It was characterized by import-substitution policies and the creation of State-led enterprises since the late 1930s, and occurred mostly in large urban centers that were expanding due to the steady immigration from rural areas. A description of this process of industrialization is found in Meller (1998).

[31] The percentage of the urban population with access to sewage and potable water increased from 25 and 54 per cent, respectively in 1965–67 and 91 per cent in 1980 (Alfaro, 1997), and continued to increase thereafter. For a discussion, see Castañeda (1990) and Alfaro (1997).

[32] This explanation is consistent with recent evidence suggesting the development of comprehensive welfare states in Northern and Western Europe during the XX century as the main factor behind the advantage of contemporary Europeans over Americans in biological standard of living (thus reversing the situation of the XIX century), in spite of the United States' high per capita income (Komlos and Baur, 2004).

Appendix 1

Description of the 38 studies reporting height-by-age, Chile 1899–2003.

No.	Study	Survey year	Birth cohorts	Ages	Sex (sample size)	Sample location	Urban–rural	Sample description and SES as reported by authors
1	Moraga del Hoyo (1899)	1898	1878–1888	10–20	M (159)	Santiago & Valparaíso	Urban	Mixed SES (1)
2	Matus Zañartu (1911)	1907	1886–1896	10–20	M (881)	Santiago	Urban	Students, IMBA boarding school
3	Matus Ugarte (1930)	1924	1889–1913	6–20	M (9750)	Santiago	Urban	Upper-middle class students*
4	Del Solar (1929)	1928	1913–1922	6–15	M (9244), F (11668)	Santiago & Valparaíso	Urban	Students, mixed SES (2)
5,6	Jimenez (1934) in Allende (1939)	1934	1922	12	M (400)	Santiago	Urban	Primary school students
	Mardones and Sépulveda (1934) in Allende (1939)	1934	1920–1925	9, 14	F (520)	Santiago	Urban	School children, sons of workers
7	Ortega (1935)	1935	1920–1930	5–14	M (272), F (603)	Santiago	Urban	Students, mixed SES
8,9	Riquelme (1942)	1940	1922–1931	6–15	M, F (202)	Conchalí	Rural	Students sons of peasants/workers
	Bustamante (1937) in Riquelme (1942)	1937	1922–1930	7–15	M, F	Santiago	Urban	Primary school students
10	Parry (1939)	1937	1919–1925	12–18	M (3677)	Santiago	Urban	Well-off students
11	Alvial (1940)	1940	1923–1931	9–17	F (1006)	Greater Concepción	Urban, some rural	Primary school students
12	Illanes and Correa (1944)	1944	1928–1937	7–14	M (56), F (52)	Santiago	Urban	School children
13	Giacaman (1945)	1945	1926–1940	8,9, 17	M (68), F (69)	Greater Concepción	Urban, some rural	Mixed SE status (3)
14	Durán (1946)	1946	1930–1939	7–16	M (391), F (309)	Santiago	Urban	Orphans in residential institutions
15	Mesa (1948)	1947	1927–1942	5–20	M (3720), F (1099)	Santiago	Urban	Well-off students
16	Royo (1948)	1948	1932–1945	3–16	M (608), F (478)	Santiago	Urban	Students, sons of workers
17	Burkhardt (1949) in Cusminsky and Fleishman (1968)	1949	1953–1958	10–15	M, F, (6653)	Santiago	Urban	Primary school students
18	Muñoz (1950) in Cusminsky and Fleishman (1968)	1950	1937–1943	7–13	M (500)	Santiago	Urban	Primary school students
19	Jadresic (1950)	1950	1930–1934	16–20	M (90)	Santiago	Urban	Students, IMBA boarding school
20	Saavedra (1954) in Cusminsky and Fleishman (1968)	1954	1942–1948	6–12	M, F,535	San Miguel	Urban, some Rural	Working-class children
21	Viel (1954) in Cusminsky and Fleishman (1968)	1954	1940–1945	9–14	M (5989)	Santiago	Urban	Well-off students
22	Norris Cumming (1952)	1958	1938–1947	5–14	M (188809), F (12336)	Santiago	Urban	Students, sons of employees
23	Stegen and Barros (1960)	1957	1945–1955	0–15	M (935), F (873)	Valparaíso	Urban and Rural	Poor, working-class children
24	ICNND, US (1961)	1961	1945–1955	5–16	M (987), F (712)	Santiago	Urban	Students
25	Montoya and Ipinza (1964)	1963	1956–1957	5–17	M (210), F (194)	Santiago	Urban	Well-off pre-school students
26	Monckeberg et al. (1967a,b)	1966	1961	6	M (16)	Curicó Province	Urban and rural	Pre-school children, mixed
27	Araya et al. (1974)	1974	1959	6–20	M (567), F (500)	Santiago	Urban	Students, mixed SES (5)
28	Avendaño et al. (1974)	1971–72	1954–1968	6–20	M (1347), F (1238)	Northern Santiago	Urban	Students, middle SES
29	Valenzuela and Avendaño (1979)	1971–72	1954–1968	6–20	M (2257), F (1878)	Northern Santiago	Urban	Students, middle SES
30	Patri et al. (1984)	1976	1970–1971	5–6	M,F (438)	Northern Santiago	Urban	Middle SES
31	Beas et al. (1986)	1986	1968–1978	8–18	M (263)	Santiago	Urban	Students, middle and Upper SES
32	Moreno (1994)	1988–94	1972–1979	10–17	M (583), F (519)	Region of Antofagasta	Urban and Rural	Students, mixed SES (4)
33	Valenzuela and Avendaño (1988)	1971–72	1968–1983	5–20	M (500), F (500)	Northern Santiago	Urban and Rural	Students, middle SES
34	Youlton and Valenzuela (1990)	1985	1966–1987	0–17	M (7500), F (7500)	Santiago	Urban	Upper and upper-middle SES
35	Ivanovic et al. (1991)	1986–87	1968–1981	5–18	M (2241), F (2110)	Metropolitan Region	Urban, some rural	Students, mixed SES (4)
36	Amigo et al. (1995)	1995	1988	7	M (2292), F (2320)	Santiago	Urban	Students, upper and middle SES
37	Valenzuela (1997)	1996	1975–1988	7–20	M (500), F (500)	Northern Santiago	Urban	Students, lower and middle SES
38	Burrows et al. (2004)	2003	1988–1997	6–15	M (1561), F (1227)	Santiago	Urban	Students, mixed SES (5)

Mixed SES (1): Study considers working-class boys, seamen, infantry, infantry musicians, blacksmiths, carpenters, boilermakers, stable boys, medical students and elementary school students. Mixed SES (2): Children in primary schools, assessed in hospitals, Civil Registry and Medical Institute for Students (Instituto Médico Escolar). Mixed SES (3): School students, preschool children, University Students, Blue-collar workers, Peasants, Administrative employees, Military. Mixed SES (4): According to a Graffar Scale, High, Middle, Lower-Middle and Low SES. Mixed SES (5): All SES are represented, using an explicit sampling procedure.
n.a.: Not Available.

* Quoted in Riquelme (1942).

Appendix 2

Detailed description of selected samples in Table 1.

Moraga del Hoyo (1899) examines vital lung capacity in 519 males aged 10–40 from Santiago and Valparaíso in different trades and professions and from different SES. To obtain a lower SES sample we selected 73 boys ages 11–18 (23 teenage seamen and seafarers, 19 infantry soldiers and other soldiers with less than a year in service, 21 over-age or repeat elementary school students[33] (aged11 or more) and 10 stable boys from a public transportation company). We thus excluded primary students of regular school-going age (6–10 for 4-year primary education in the early 1900s), university students, cavalry soldiers (of higher SES and recruited more selectively than infantry) as well as apprentices of middle-class trades and professions around 1900 (policemen, carpenters and workers from the State railway company). The selected sample may under-represent the poorest boys in Chile in the 1900s (poor and uneducated children, street boys and occasional teenage laborers).[34]

Matus Zañartu (1911): Instituto Nacional Barros Arana (INBA) was c 1900 a prestigious and selective secondary public boarding school for the sons of upper and upper-middle class families from Santiago and other important cities in central Chile. INBA had privileged public resources and infrastructure, and European teachers were often hired. The Institute produced influential and renowned professionals, politicians and intellectuals, many of whom also sent their sons to INBA. The sample was taken in 1907.

Mesa (1948) reports height measurements of 3706 healthy boys aged 6–18 from affluent urban schools participating in the *Servicio Médico Escolar*. 56.1% were upper SES students from *Humanidades* secondary schools (as preparation for university education).[35] Another 19.3% were students from private primary schools from upper SES, and 24.6% were students from high-status public primary schools (Royo, 1948, p. 23). Weight-for-age and nutritional status of this sample was judged "good" or "adequate" for 96% of the sample (p. 36), in contrast with other contemporary nutritional studies for school-age children. The average BMI for age of individuals in the sample is close to the 50th centile reported in modern BMI-for-age charts.

Royo (1948): This sample had height measurements of 530 males aged 6–16, described by the author as "working-class background" and "lower-class" (*clase baja*). The sample included children from two sources: (i) children from the borough of Quinta Normal, a poor borough in the semi-rural periphery of Santiago[36] and (ii) children from *Ciudad del Niño*, a public residential institution founded in 1943 for abandoned or neglected children See García (1943).

Ivanovic et al. (1991): this investigation followed an explicit sampling procedure to gather a representative sample of students in the Metropolitan Region of Chile (greater Santiago), which contains about 40 per cent of the Chilean population. 4509 students from 13 schools in 8 boroughs were surveyed. SES was determined using a Modified Graffar scale, based on the schooling and occupation of the household head and characteristics of the dwelling. Six SE groups were defined (High–High, High–Middle, Middle, Low–Middle, Low and Misery), from which High SES was finally constructed from the top two, Middle SES from the third, and Low SES from the bottom three categories.

Appendix 3

OLS and quantile regressions, without cohort and age interactive effects, cohorts 1880–1997 and 1930–1997.

	Cohorts 1880–1997	Cohorts 1930–1997	Cohorts 1880–1997 quantile regressions			Cohorts 1930–1997 quantile regressions		
	OLS	OLS	Q20	Q50	Q80	Q20	Q50	Q80
Year of birth (YB)	0.107**	0.123**	0.132**	0.094**	0.087**	0.142**	0.152**	0.101**
Age	24.367**	26.859**	34.325**	31.252**	19.238**	32.956**	33.146**	33.733**
Age^2	−3.093**	−3.489**	−4.325**	−4.200**	−2.486**	−4.146**	−4.415**	−4.500**
Age^3	0.207**	0.234**	0.271**	0.278**	0.181**	0.263**	0.291**	0.299**
Age^4	−0.005**	−0.006**	−0.006**	−0.007**	−0.005**	−0.006**	−0.007**	−0.007**
Constant	29.380*	22.116	−3.306	16.076	47.761	−0.846	4.745	9.120
Observations[a]	447	362	447	447	447	362	362	362
R-squared	0.96	0.97						
Pseudo *R*-squared		0.81	0.83	0.82	0.83	0.85	0.84	

Robust standard errors in parentheses.

Superscript 2, 3 and 4 shows powers of the variable "Age", respectively, which are included as regressors in the shown regressions.

[a] An observation is the mean height of the boys of the same age and year of birth in every one of the 447 samples derived from the studies in Appendix 1.

* $p < 0.05$.

** $p < 0.01$.

[33] Public primary schools in Chile c. 1900 were divided into "Elementary" (attended mostly by middle and lower-middle class children) and "Superior" (more demanding and attended by urban upper-middle and upper class children). A significant proportion of school-age children would not regularly attend school around 1900 (Egaña, 2000). A sample of lower SES boys was made considering over-age and repeat students from this sample, based on the theory and evidence associating delayed children in primary education with lower SES (Glewwe and Jacoby, 1995).

[34] See Salazar and Pinto (2002) for a historical description of this population in the XIX and early XX century.

[35] The secondary *Humanidades* schools were inspired by the *lycées* in France, the *gymnasium* in Germany and *Grammar Schools* in the UK.

[36] The 1952 National Census reports that Quinta Normal borough had a higher illiteracy rate than the average for Greater Santiago (15 vs. 9 per cent, respectively), and lower school attendance among school-age children ages 7–10 (78 vs. 85 per cent, respectively).

Appendix 4

OLS and quantile regressions with cohort and age interactive effects, cohorts 1880–1997.

		Quantile regressions		
	OLS	Q20	Q50	Q80
Year of birth (YB)	−0.465**	−0.748**	−0.715**	−1.398**
Age	4.965**			−18.020*
Age^2		0.191**	0.355**	2.097**
Age^3[a]			−7.721**	−58.910**
Age^4				
YB × age	0.253**	0.293**	0.328**	0.530**
YB × age^2	−0.041**	−0.039**	−0.048**	−0.067**
YB × age^3[a]	2.750**	2.448*	3.099**	3.609**
YB × age^4[a]	−0.065**	−0.057**	−0.072**	−0.071**
Constant	73.839**	99.203**	93.545**	154.173**
Observations[b]	447	447	447	447
R-squared	0.97			
Pseudo *R*-squared	0.82	0.83	0.83	

Robust standard errors in parentheses.
Superscript 2, 3 and 4 shows powers of the variable "Age", respectively, which are included as regressors in the shown regressions.
[a] The estimated coefficients have been multiplied by 1000.
[b] An observation is the mean height of the boys of the same age and year of birth in every one of the 447 samples derived from the studies in Appendix 1.
* $p < 0.05$.
** $p < 0.01$.

Appendix 5

Public social expenditure and selected social and economic indicators, Chile 1900–1990.

		1905–7	1920	1930	1940	1950	1960	1970	1980	1990
Total Social Public Spending[a] (as % share of GDP)		1.1	1.0	2.7	3.6	5.2	8.6	10.5	10.3	12.5
Education		1.1	1.0	1.7	1.9	2.4	2.6	3.3	3.5	
Health		0.0	0.0	1.0	0.6	0.7	2.2	2.0	3.2	
Pensions & Social Welfare		0.0	0.0	0.0	0.7	1.4	3.1	2.6	3.0	
Housing & Urban Planning		0.0	0.0	0.0	0.4	0.6	0.6	2.1	0.6	
Chile's GDP per capita, US $[b]		3000.1	2768.2	2858.8	3236.2	3669.7	4270.3	5231.4	5680.4	6400.9
Annual GDP per capita growth, in previous 10 years			3.2	−0.8	0.3	1.2	1.3	1.5	2.1	0.8
GDP per capita (pc) relative to US[b]		0.60	0.50	0.46	0.46	0.38	0.38	0.35	0.31	0.28
GDP pc relative to W. Europe[b]		0.89	0.84	0.67	0.65	0.73	0.56	0.48	0.41	0.38
GDP pc relative to Latin America[b]		1.92	1.68	1.49	1.52	1.36	1.26	1.21	0.96	1.17
Life Expectancy at Birth[c] (years)	Female		32.2	41.8	43.0	56.8	59.9	64.7	74.2	77.3
	Male		30.9	39.5	40.7	52.9	54.4	58.5	67.4	71.4
Infant Mortality Rate (IMR)[c] (per 1000 live birhts)		297.6	263.4	233.0	217.2	153.2	119.5	82.2	31.8	16.0
IMR Latin America[d]						133	107	86	63	43
GINI Index, Greater Santiago[e]						0.50	0.52	0.56	0.53	0.57
Household Income Quantile Ratio V/I Greater Santiago[e]							13.9	15.4	12.0	12.2

Social spending figures for 1940 and 1950 are interpolations from 1935 to 1945 and 1945 to 1955 of the source, respectively.
[a] Arellano (1985).
[b] "Historical Statistics of the World Economy, 1–2006 AD", Ggdc, Angus Maddison (2009), www.ggdc.net/maddison/historical,/horizontal-file_03–2009.xls (original data in 1990 International Geary-Khamis dollars); data for 1905–7 correspond to 1910 data in source.
[c] Braun et al. (2000).
[d] United Nations (2011), interpolations from 5-year data in the source.
[e] Ruiz-Tagle (1999).

References

Aguila, A., Muñoz, H., 1997. Trends in birth rates, general, infantile and neonatal mortality in Chile from 1850 to date. Revista Médica Chilena 125 (10) 1236–1245.

Allende, S., 1939. La Realidad Médico Social Chilena. Ministerio de Salubridad, Santiago, Chile.

Alter, G., Neven, M., Oris, M., 2004. Stature in transition – a micro-level study from nineteenth-century Belgium. Social Science History 28 (2) 231–247.

Alvial, B., 1940. Contribuciones al Estudio de la Antropología Chilena. Boletín Sociedad Biológica de Concepción Tomo XIV, 79–101.

Amigo, H., Bustos, P., Radrigán, M.E., Ureta, E., 1995. Estado Nutricional en Escolares de Nivel Socioeconómico Opuesto. Revista Médica de Chile (123) 1063–1070.

Araya, J., Araya, H., Arteaga, A., Ávila, B., Barja, I., Boj, M.E., Buitrago, M., Cabrera, L., Castro, N., Colombara, E., Godoy, R., Pak, N., Rosales, E., Valiente, S., 1974. Informe sobre Situación Nutricional del Menor en Chile. Departamento de Nutrición, Facultad de Medicina, Universidad de Chile. Conicyt, Proyecto: Estudio del Menor en Chile, Sector Nutrición.

Arcaleni, E., 2006. Secular trend and regional differences in the stature of Italians, 1854–1980. Economics & Human Biology 4 (1) 24–38.

Arellano, J.P., 1985. Políticas Sociales y Desarrollo: Chile 1924–1984, primera edición. Cieplan, Santiago de Chile.

Avendaño, A., Valenzuela, C., Patri, A., Cerda, M.E., Figueroa, L., Villalón, H., Sierra, G., Saavedra, I., Wildner, E., 1974. Antropometría de Escolares Chilenos del Área Norte de Santiago. Antropometría y Salud 5–21.

Baten, J., Pelger, I., Twrdek, L., 2009. The anthropometric history of Argentina, Brazil and Peru during the 19th and early 20th century. Economics & Human Biology 7 (3) 319–333.

Beas, F., Barrera, R., Corvalán, L., Cortínez, A., Eggers, M., Henríquez, C., 1986. Parámetros antropométricos en varones adolescentes chilenos de nivel socioeconómico medio-alto. Revista de Pediatría 57 (6) 485–490.

Bielecki, E., Haas, J., Hulanicka, B., 2012. Secular changes in the height of Polish schoolboys from 1955 to 1988. Economics & Human Biology 10 (3) 310–317.

Bogin, B., 1998. Patterns of human growth. In: Ulijaszek, S., Johnston, F., Preece, M. (Eds.), The Cambridge Encyclopedia of Human Growth and Development,. Cambridge University Press, Cambridge, UK.

Braun, J., Braun, M., Briones, I., Díaz, J., Luders, R., Wagner, G., 2000. Economía Chilena 1810–1995, Estadísticas Históricas. Documento de Trabajo 187, Instituto de Economía, Pontificia Universidad Católica de Chile.

Burrows, R., Muzzo, S., Cordero, J., Ramírez, I., 2004. Trends in nutritional status and stature among school-age children in Chile. Nutrition 20 (10) 867–872.

Cardoso, H., Caninas, M., 2009. Secular trends in social class differences of stature, weight and BMI of boys from two schools in Lisbon, Portugal (1910–2000). Economics & Human Biology 8 (1) 111–120.

Castañeda, T., 1990. Para combatir la pobreza: Política social y descentralización en Chile durante los 80s. Centro de Estudios Públicos, Santiago de Chile.

Cavelaars, A., Kunst, A., Geurts, J., Crialesi, R., Grötvedt, L., Helmert, U., Lahelma, E., Lundberg, O., Mielck, A., Rasmussen, N., Regidor, E., Spuhler, T., Mackenbach, J., 2000. Persistent variations in average height between countries and between socio-economic groups: an overview of 10 European countries. Annals of Human Biology 27, 407–421.

Cernerud, L., Elfving, J., 1995. Social inequality in height. Scandinavian Journal of Social Medicine 23 (1) 23–27.

Challú, A., 2009. Agricultural crisis and biological well-being in Mexico, 1730–1835. Historia agraria: Revista de agricultura e historia rural (47) 21–44.

Cole, T.J., 2003. The secular trend in human physical growth: a biological view. Economics & Human Biology 1 (2) 161–168.

Collier, S., Sater, W., 2004. A history of Chile, 1808–002, Cambridge Latin American Studies. Cambridge University Press.

Collier, S., Skidmore, T., Blakemore, H., 1992. The Cambridge Encyclopedia of Latin America. Cambridge University Press, Cambridge, UK.

Cusminsky, M., Fleishman, R., 1968. Análisis de los trabajos realizados sobre el crecimiento de niños en Santiago, Chile. Años 1940–1966 Revista Chilena de Pediatría, , pp. 891–913.

Del Solar, L., 1929. La Defensa del Niño en la Edad Escolar, Medidas antropométricas de nuestro niño en la edad comprendida entre los 6 y los 15 años, Memoria para optar al Título de Cirujano. Universidad de Chile, , pp. 49–101.

Dragoni, C., Burnet, E., 1938. La Alimentación popular en Chile, Primera encuesta general de 1935. Revista Chilena de Higiene y Medicina Preventiva 10–12, 409–611.

Durán, J., 1946. Somatometría y Estado Nutritivo en Escolares Primarios, Tesis para optar al título de Médico Cirujano. Universidad de Chile.

Egaña, M., 2000. La Educación Primaria Popular en el Siglo XIX en Chile: Una práctica de Política Estatal, LOM Ediciones, Santiago de Chile.

Eveleth, P., Tanner, J., 1990. Worldwide Variations in Human Growth, 2nd ed. Cambridge University Press.

Frank, Z., 2006. Stature in nineteenth-century Rio de Janeiro: preliminary evidence from prison records. Revista de Historia Económica 24 (3) 465–489.

García, H., 1943. Ciudad del Niño Presidente Ríos: ellos serán felices. Libro o Archivo de la Biblioteca Nacional sobre el Proyecto la Inauguración y las personas que ayudaron a crear la Ciudad del Niño Presidente Ríos. Editorial Zig-Zag S.A. and Dirección General de Informaciones y Cultura. Santiago de Chile.

Giacaman, P., 1945. Determinantes del Índice Metabólico en la Población de Concepción. Boletín de la Sociedad de Biología de Concepción XX, 61–76.

Glewwe, P., Jacoby, H., 1995. An economic analysis of delayed primary school enrollment in a low income country: the role of early childhood nutrition. Review of Economics and Statistics 77 (1) 156–169.

Grajales-Porras, A., López-Alonso, M., 2011. Physical stature of men in eighteenth century Mexico: evidence from Puebla. Economics & Human Biology 9 (3) 265–271.

Greene, W., 2011. Econometric Analysis, 7th ed. Prentice Hall.

Grez, S., 1997. La cuestión social en Chile: ideas y debates precursores: 1804–1902, DIBAM, Santiago de Chile.

Hansen, B., Cortina-Borja, M., Ratcliffe, G., 2003. Assessing non-linear estimation procedures for human growth models. Annals of Human Biology 30 (1) 80–96.

Hauspie, R., 1998. Curve fitting. In: Ulijaszek, S., Johnston, F., Preece, M. (Eds.), The Cambridge Encyclopedia of Human Growth and Development. Cambridge University Press, Cambridge, UK.

Hojman, D., 2001. The Welfare state in emerging market economies: The case of Chile. Research Papers, 2001_03 University of Liverpool Management School.

Illanes, O., Correa, O., 1944. Estudios de Capacidad Vital en Escolares Normales. Revista Chilena de Pediatría 815–829.

Ivanovic, D., Olivares, M., Ivanovic, R., 1991. Peso y estatura de escolares de la región metropolitana de Chile: Impacto del nivel socioeconómico. Revista Médica de Chile (119) 1322–1333.

Jadresic, V., 1950. Determinación del Biotipo de 160 Estudiantes mediante el Método de Sheldon. Tesis de Licenciatura en Medicina Facultad de Biología y Ciencias Médicas, Universidad de Chile.

Johnson, F., 1998. Between population differences in adolescent growth. In: Ulijaszek, S., Johnston, F., Preece, M. (Eds.), The Cambridge Encyclopedia of Human Growth and Development. Cambridge University Press, Cambridge, UK.

Karlberg, J., 1998. The human growth curve. In: Ulijaszek, S., Johnston, F., Preece, M. (Eds.), The Cambridge Encyclopedia of Human Growth and Development. Cambridge University Press.

Koenker, R., 2005. Quantile Regression. Cambridge University Press, Cambridge, UK.

Komlos, J., 1987. The height and weight of west point cadets: dietary change in antebellum America. Journal of Economic History 47 (4) 897–927.

Komlos, J., 1990. Height and social status in eighteen-century Germany. Journal of Interdisciplinary History 20 (4) 607–621.

Komlos, J., 1994. The nutritional status of French students. Journal of Interdisciplinary History 24 (3) 493–508.

Komlos, J., 2006. The height increments and BMI of elite Central European Children and youth in the second half of the 19th century. Annals of Human Biology 33 (3) 309–318.

Komlos, J., Baur, M., 2004. From the tallest to (one of) the fattest: the enigmatic fate of the American population in the 20th century. Economics & Human Biology 2 (1) 57–74.

Kuh, D., Power, C., Rodgers, B., 1991. Secular trends in social class and sex differences in adult height. International Journal of Epidemiology 20 (4) 1001–1009.

Larrañaga, O., 2010. El Estado Bienestar en Chile: 1910–2010. In: Lagos, R. (Ed.), Cien Años de Luces y Sombras, Vol. 2. Santiago de Chile.

Li, L., Manor, O., Power, C., 2004. Are inequalities in height narrowing? Comparing effects of social class on height in two generations. Archives of Disease in Childhood 89 (11) 1018–1023.

López-Alonso, M., Porras, R., 2003. The ups and downs of Mexican economic growth: the biological standard of living and inequality, 1870–1950. Economics & Human Biology 1 (2) 169–186.

Matus, M., 2009. Precios y Salarios Reales en Chile durante el Ciclo Salitrero, 1880–1930. (Tesis para optar al grado de Doctor)Universidad de Barcelona.

Matus Ugarte, H., 1930. Contribución al Estudio de la Biotipología Chilena. Tesis Escuela de Medicina Universidad de Chile, Biblioteca Nacional, , pp. 95–116.

Matus Zañartu, L., 1911. Antropometría del Niño Chileno. Revista de Instrucción Primaria, Santiago de Chile.

Meisel, A., Vega, M., 2007. The biological standard of living (and its convergence) in Colombia, 1870–2003. A tropical success story. Economics & Human Biology 5 (1) 100–122.

Meller, P., 1998. Un Siglo de Economía Política Chilena (1890–1990). Editorial Andrés Bello, Santiago de Chile.

Mesa, A., 1948. Análisis del Servicio Médico Escolar. Tesis para optar al título de Médico Cirujano Universidad de Chile.

Monckeberg, F., Donoso, G., Valiente, S., Arteaga, A., 1967a. Análisis y comentario de la encuesta nutritiva y de las condiciones de vida de la población infantil de la provincia de Curicó. Revista Chilena de Pediatría, year 35, 522–535.

Monckeberg, F., Donoso, G., Valiente, S., Maccioni, A., Merchak, N., Donoso, F., Arteaga, A., 1967b. Condiciones de vida, medio familiar y examen clínico y bioquímico de lactantes y preescolares de la provincia de Curicó. Revista Chilena de Pediatría 499–535.

Montoya, C., Ipinza, M., 1964. Peso y Estatura de Pre-escolares Santiaguinos pertenecientes a dos estratos sociales diferentes. Revista Chilena de Pediatría, Marzo, pp. 269–271.

Moraga del Hoyo, J., 1899. Contribución al Estudio de la Capacidad Vital de los Pulmones. Comunicaciones, year XXVII, N^{o} 12, pp. 340–453.

Moreno, E., 1994. Estudio de la Estatura durante la Pubertad en Escolares. Tesis Investigadores Universidad de Antofagasta, pp. 18–54.

Norris Cumming, B., 1952. Desarrollo Pondo Estatural del Niño Chileno, Tesis para optar al grado de Licenciado en Medicina, Universidad de Chile.

Ortega, R., 1935. Consideraciones sobre la tuberculosis oculta y la tuberculosis pulmonar en el escolar. Revista Chilena de Pediatría 519–555.

Parry, A., 1939. Medidas Antropométricas del Adolescente Chileno, Ediciones del Boletín de Educación Física, Boletín N°14, Octubre, 782–802, Asesor Técnico Dirección General de Estadística.

Patri, A., Sepúlveda, H., Valenzuela, C., Cortés, O., 1984. Antropometría del Niño Chileno de 0 a 6 Años. Editorial Andrés Bello, , pp. 4–58.

Riquelme, A., 1942. Alimentación en la Edad Escolar: Encuesta y Estudio Experimental en medio rural, Impr. Universo, Santiago de Chile.

Romero, L., 1997. ¿Qué hacer con los pobres? Elite y sectores populares en Santiago de Chile 1840–1895, Editorial Sudamericana, Buenos Aires. .

Rona, R., 1975. Secular trend of pubertal development in Chile. Journal of Human Evolution 4, 251–257.

Rosselot, J., 1993. Origen, Desarrollo y Perspectivas de las Instituciones de Salud Pública en Chile. Revista Médica de Chile 121, 1075–1085.

Royo Jara, O., 1948. Investigación sobre el Estado Nutritivo en 1167 Niños de Clase Obrera, Tesis para optar al título de Médico Cirujano, Universidad de Chile.

Ruiz-Tagle, J., 1999. Chile: 40 años de desigualdad de ingresos. Series Documentos de Trabajo, Departamento de Economía, Universidad de Chile, Noviembre.

Salazar, G., Pinto, J., 1999. La Presencia Inmigrante. Historia Contemporánea de Chile LOM Ediciones, Santiago de Chile, pp. 76–81.

Salazar, G., Pinto, J., 2002. Historia Contemporánea de Chile V: Niñez y Juventud, LOM Ediciones, Santiago de Chile.

Salvatore, R., 2004. Stature decline and recovery in a food-rich export economy: Argentina 1900–1934. Economics & Human Biology 41 (3) 233–255.

Salvatore, R., 2009a. Stature growth in industrializing Argentina: the Buenos Aires industrial belt 1916–1950. Explorations in Economic History 46 (1) 70–92.

Salvatore, R., 2009b. The regional dimension of biological welfare: Argentina in the 1920s. Historia agraria: Revista de agricultura e historia rural (47) 187–215.

Santa María, J., 1941. Características de la Alimentación en Chile. Revista Médica de Chile LXIX (6) 308–322.

Solimano, G., Unda, H., Alvarez, A., 1972. Programa Nacional de Leche. Cuadernos Médicos Sociales XIII (4) 10–23.

Stegen, G., Barros, M., 1960. Consideraciones sobre Medidas Antropométricas en el Niño Sano y Desnutrido. Revista Chilena de Pediatría 3 (3) 132–139.

Subramanian, S., Özaltin, E., Finlay, J., 2011. Height of nations: a socioeconomic analysis of cohort differences and patterns among women in 54 low- to middle-income countries. PLoS ONE 6 (4) e18962, http://dx.doi.org/10.1371/journal.pone.0018962.

Szot Meza, J., 2003. La transición demográfico-epidemiológica en Chile, 1960–2001. Revista Española de Salud Pública 77 (5) 605–613.

Ulijaszek, S., 1998. Modernization and growth. In: Ulijaszek, S., Johnston, F., Preece, M. (Eds.), The Cambridge Encyclopedia of Human Growth and Development,. Cambridge University Press.

Ulijaszek, S., Johnston, F., Preece, M., 1998. The Cambridge Encyclopedia of Human Growth and Development. Cambridge University Press.

United Nations, Department of Economic and Social Affairs, Population Division, 2011. World Population Prospects: The 2010 Revision, New York (comprehensive Excel tables).

United States, 1961. Interdepartmental Committee on Nutrition for National Defense. Chile: Nutrition Survey, March–June 1960: a report. Washington.

Valenzuela, C., 1997. Evaluación de la Estatura como Indicador Nutricional Poblacional. Revista Médica de Chile (125) 595–604.

Valenzuela, C., Avendaño, A., 1979. Antropometría y Maduración Sexual de Escolares de un Área de Santiago de Chile. Boletín Oficina Sanitaria Panamericana 87 (2) 113–130.

Valenzuela, C., Avendaño, A., 1988. Seguimiento Longitudinal de Crecimiento y Desarrollo 6 a 20 Años de Edad, Área Norte Santiago. Revista de Pediatría 31, 4–58.

Vignerová, J., Brabec, M., Bláha, P., 2006. Two centuries of growth among Czech children and youth. Economics & Human Biology 4 (2) 237–252.

Youlton, R., Valenzuela, C., 1990. Patrón de crecimiento en estatura y peso de 0 a 17 años y de circunferencia craneana de 0 a 2 años de niños de estratos socioeconómicos medio-alto y alto de Santiago, Comparación con el crecimiento de niños de estratos socioeconómicos medio-bajo y bajo del Área Norte de Santiago. Revista Chilena de Pediatría 31, 1–22.

Zellner, K., Jaeger, U., Kromeyer-Hauschild, K., 2004. Height, weight and BMI of schoolchildren in Jena, Germany-are the secular changes levelling off? Economics & Human Biology 2 (2) 281–294.