



Height in twentieth-century Chilean men: growth with divergence

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Abstract

This article provides the first series of Chilean adult male height for the whole of the twentieth century. The height of adult males increased by about 5.5 cm during the twentieth century, primarily during the second half of this period. This is the greatest improvement in biological welfare in Chilean history; Chilean males have never been as tall as they are today. Using a sample of around 36,371 individuals, we document the evolution of the average height of Chilean soldiers (male) born from the 1900s to the 1990s. This sample can be safely taken as a good proxy of the average height of Chilean male population for the period under study. We provide an explanation of both the main determinants of physical stature and the rapid increase in height in Chile over this period.

Keywords Height · Chile · Living conditions · Twentieth century

JEL Classification N36 · I12

1 Introduction

Until recently, the anthropometric history of Chile had been insufficiently researched, in particular if compared to other countries of the region such as Mexico (Carson 2005; Grajales-Porras and López-Alonso 2011; Challú 2009, 2010; López-Alonso and Porras-Condey 2003; López-Alonso and Grajales-Porras 2015; López-Alonso 2007, 2015), Brazil (Frank 2006; Baten et al. 2009; Monasterio 2013; Franken 2019), Argentina (Salvatore 1998, 2004, 2007, 2009, 2019; Baten et al. 2009), and Colombia (Meisel

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and Vega 2007; Acosta and Meisel 2013; Jaramillo-Echeverri et al. 2019). Before 2018, there was only one published study on Chilean height: Núñez and Pérez (2015), which deals with height in boys rather than adults. During the last 2 years, though, three additional studies have been published covering the eighteenth and nineteenth centuries: Llorca-Jaña et al. (2018a, 2019, 2020a). However, no published research has dealt with physical stature for the whole of the twentieth century, except for Llorca-Jaña et al. (2018b), which covers the 1730s–1980s and deals with a small sample of less than 3000 observations, and Borrescio-Higa et al. (2019), which covers the 1960s–1980s only (based on a small health survey). This is the first article to analyse the entirety of the twentieth century in Chile, with a sizeable sample of over 36,000 observations.

Comparatively little research has been undertaken on the twentieth century in Latin America, including countries which have been studied anthropometrically, although Mexico (López-Alonso and Porrás-Condey 2003; López-Alonso and Grajales-Porrás 2015; López-Alonso 2007, 2015), Brazil (Baten et al. 2009; Monasterio 2013), and Colombia (Meisel and Vega 2007; Acosta and Meisel 2013; Jaramillo-Echeverri et al. 2019) are exceptions to the rule. While the colonial era, the nineteenth century, and the early twentieth century in Argentina have been extensively researched (Salvatore 2004, 2007, 2009, 2019), no data-based research has been published after the 1950s.

The lack of research on the evolution of adult height during the second half of the twentieth century is not confined to Latin American anthropometric history. As has been noted in WEHC 2018,¹ there are fewer worldwide anthropometric studies concerned with the second half of the last century than for previous periods. This is a puzzle since in the 1950s–1960s adult height started to increase dramatically, in Chile and globally. Possibly this lack of research on adult height during the 1950s–1990s can be attributed to the abundance of good data on alternative indicators of economic development (a factor which does not apply to the eighteenth and nineteenth centuries, when physical stature is one of the few (sound) indicators available to researchers). Yet, the evolution of physical stature during the last five or six decades cannot be ignored: the biological welfare of the population should remain a key area of interest for contemporary policy makers.

The aim of this article is to provide the first series of adult height for Chile during the whole of the twentieth century, including an analysis of its long-term evolution; and to assess the key determinants of physical stature during this period. We compare height evolution in Chile with other countries, both in Latin America and elsewhere, and determine whether the country converged or diverged regarding biological welfare during the 1900s–1990s.

This article is organised as follows. The following section provides a brief sketch of Chilean economic history during the twentieth century, to provide a context for the evolution of height during this period. We then discuss the sources of information and the methodology used to estimate the evolution of height. Finally, we discuss our results and relate them to the most important developments affecting the human body in Chile, followed by a comparison with some other countries for which there is evidence available.

¹ See Joerg Baten and Kris Inwood, “Proposal preview”, <http://wehc2018.org/the-most-dramatic-period-globally-for-the-development-of-the-human-body-the-20th-century/>, accessed on 30 November 2018.

2 The twentieth-century Chilean economy

Chilean economic historians frequently divide the history of the country into five broad periods: the colonial; the early republic (c.1810s–1870s); the nitrate era (c.1880s–1920s), featuring export-led growth; inward looking development or state-led industrialization (c.1930–1973); and the neoliberal age (from c.1973 to the present). This article covers the second half of the nitrate era, the whole period of inward looking development (or of substantial state intervention in economic affairs), and the neoliberal era.

The nitrate era was characterised by booming exports, in particular of nitrate,² in a clear episode of export-led growth, the first experienced by the country.³ Never before had the country reached such a level of per capita exports (Meller 2016). Chile's export economy has always been heavily based on minerals, to an extent unequalled in Latin America except in twentieth-century Venezuela (Miller and Llorca-Jaña 2019). The Chilean macro-economy flourished during the nitrate era. During 1880–1929, Chilean per capita GDP more than doubled (Fig. 1). Inflation was, on average per decade, below 7% (Díaz et al. 2016). There were also considerable investments in infrastructure, and education, in part funded by increasing fiscal revenues, coming from export duties on nitrate (Castillo 2016; Meller 2016). The public sector increased in size, and with it government expenditure. Finally, the industrial sector slightly improved its share within the whole economy, but there was no structural change in the Chilean economy (Ducoing and Badia-Miró 2013). There was economic growth, but little development (Matus 2012).

The Great Depression of 1929 was a watershed in Chilean economic history: the impact on the country's export sector was worse than that in any other country in the region, according to the classic historiography (Bulmer-Thomas 2014; Meller 2016), although its impact on the real economy may be exaggerated (see below). As in many other countries in the region, the deep economic crisis was blamed on the export sector and local elites. There was, therefore, a shift towards policies based on Import Substitution Industrialization (Miller and Llorca-Jaña 2019). Industrialization was then seen as the solution to the crisis and the beginning of national development. The success of this strategy, though, was limited (Meller 2016 and Fig. 1). The macroeconomic balance of the inward looking development period, ended by Pinochet's bloody military coup, was poor. The real per capita GDP of 1973 was just 42% higher than that achieved in 1929 (Fig. 1). However, there were some fundamental changes in the structure of the economy: extensive agrarian reform took place, and greater state intervention in the economy (Meller 2016), which increased during Allende's short term in office (1970–1973).⁴ Yet, the export sector remained highly concentrated in one commodity only. Thereafter, there was some

² The share of nitrate within total exports was about 80% during the 1910s (Cariola and Sunkel 1982).

³ In 1830 exports accounted for 7% of GDP, while during the 1890s–1910s, this ratio was above 20% (Badia-Miró and Díaz 2017).

⁴ By September 1973, CORFO managed to control around 500 industrial, commercial, banking, and other establishments (Lefort 2010; Nazer 2020).

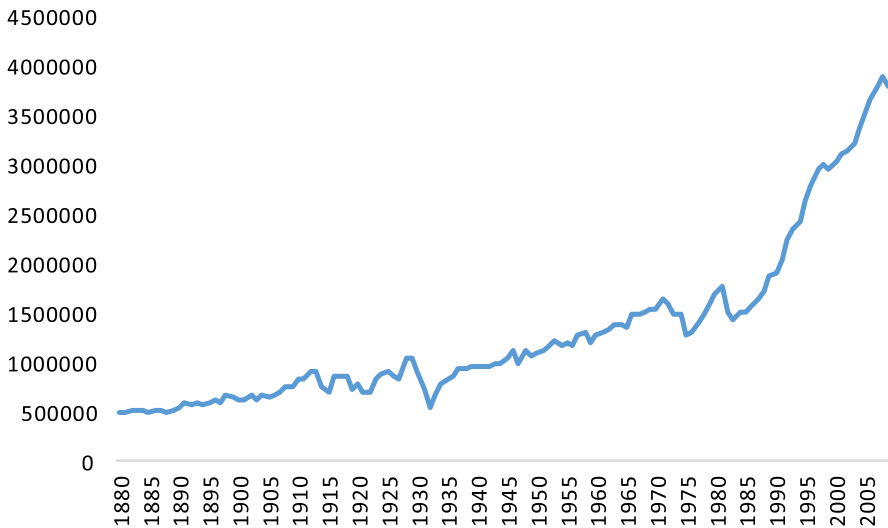


Fig. 1 Chile's real per capita GDP, 1880–2007 (pesos of 2003). *Source:* Díaz et al. (2016)

diversification in the export basket: more goods entered the export sector, beyond mining.

The neoliberal era can be divided, politically, into two periods: Pinochet's dictatorship (1973–1990) and the democratic era (1990–2019). During the first of these sub-periods, there were some radical reforms: agrarian reform was reverted, most state companies were privatised or reprivatised (Monckeberg 2012; Gárate 2012), as were the pension system and most of the health sector, the external sector was liberalised, prices were also liberalised and the financial sector more generally, and most economic activity deregulated: these were the years of most pronounced *laissez-faire* in Chile (Meller 2016). For Pinochet's economic advisors (the so-called Chicago Boys), a fundamental economic principle was that the state should not engage in any business, and that the labour market should be more flexible or deregulated (Barría 2015; Gárate 2012). During this period, together with political repression and lack of liberty, there was a profound economic crisis in 1982–1983 (the worst in 50 years), which ended with a brief period of economic prosperity that had started in the late 1970s. Overall, the economic performance of Chile during the entire dictatorship was poor: the compound annual growth rate of real per capita GDP was just 1.55% (lower than in preceding periods), the external debt of the country increased significantly, and unemployment was high, while inflation also remained a serious concern (in particular during 1973–1976 and 1982–1985).

The political and international isolation of the Chilean economy ended in 1990, with the return of democratic government, although the major macroeconomic policies remained the same as they had been under Pinochet's dictatorship. This time the macroeconomic performance of the country was much better: low inflation and higher economic growth. One area that changed dramatically was trade policy. From

1990, many bilateral trade treaties were signed with strategic partners, promoting Chile's agricultural exports (Llorca-Jaña 2015; Martínez 2015). The country now began to export sizeable quantities and varieties of different agricultural products. The export basket diversified significantly, although copper remained the major export in the international markets (Miller and Llorca-Jaña 2019). There were also important social policies implemented, which successfully reduced poverty.

It is important to address changes in the Chilean population during our period of study. The first census undertaken in the country in the twentieth century was that of 1907, which estimated the total population as 3.2 million people. The population grew, but growth increased substantially after the mid-1940s. The 1950s–1990s witnessed a large increase in the Chilean population, and falling death rates (Mamalakis 1976; Díaz et al. 2016). The centre of the country (to which Santiago and Valparaíso belong), accounted for between 55 and 62% of all population and was always above 60% during the 1960s–1990s. The second most populated macro-zone was the South, with a stable 27–31% of all population. The less populated zone was the North, which decreased from 15% in 1907 (in the middle of the nitrate boom) to 10–11% during the 1950s–1990s. This period was also marked by a dramatic increase in urbanization: at the beginning of the century, the rate of urban population over total population was slightly over 40%, but by the end of the century, it was over 80% (Díaz et al. 2016) (Table 1).

3 Sources and methodology

Data on height were collected from military records for adult males. These military records relate mainly to soldiers or low-ranked officers (e.g. corporals and sergeants, rather than high-ranking military officers), who were representative of lower socio-economic groups, thus accounting for the bulk of the population in Chile [and reflecting the high levels of inequality in the country (Rodríguez 2017)]. In particular, we have resorted to an untapped collection, namely 2236 loose volumes from the *Archivo Histórico del Ejército* (Army's Historical Archive, AHE, hereafter). This collection, long available but unseen by researchers, contains filiation sheets, contracts, claim sheets, and medical records of members of the regular army, as well as of retired personnel. To avoid any repetition of observations, we entered the full name of the conscripts/soldiers and deleted all repeated names.

Despite its wealth of information, our sample of soldiers is not complete and contains roughly 5–7% of men entering conscription.⁵ Files were not complete in part because only a fraction of the original data survived, in part because we were also denied access to some particular folders (e.g. those of high-ranking officers and some soldiers still on duty). It is important to note that we did not sample; we

⁵ Unfortunately, the share of our sample from the total male population varies over time, with an average of 7% for those in their 20 s and an average of 5% for those in the 17–19 age range. The share of those in their 20 s, the most relevant age group in our sample, reached its highest value in the 1950s (16%) and its lowest share in the 1990s (1.2%).

Table 1 Chilean population during the twentieth century (population per broad regions and their shares within the national population). *Source:* Own elaboration from Censuses of the republic, available at the Institute of National Statistics: http://historico.ine.cl/canales/usuarios/censos_digitalizados.php

Year of census	North	Centre	South	Total
1907	491,096	1,803,086	955,097	3,249,279
1920	520,464	2,052,648	1,180,687	3,753,799
1930	551,530	2,374,703	1,361,212	4,287,445
1940	579,165	2,828,076	1,614,234	5,021,475
1952	629,895	3,478,615	1,824,485	5,932,995
1960	763,515	4,462,138	2,148,260	7,373,913
1970	919,718	5,541,866	2,423,184	8,884,768
1982	1,220,209	6,845,433	3,264,094	11,329,736
1992	1,485,563	8,174,783	3,688,055	13,348,401
2002	1,780,124	9,289,761	4,046,550	15,116,435
Year of census	North (%)	Centre (%)	South (%)	Total (%)
1907	15	55	29	100
1920	14	55	31	100
1930	13	55	32	100
1940	12	56	32	100
1952	11	59	31	100
1960	10	61	29	100
1970	10	62	27	100
1982	11	60	29	100
1992	11	61	28	100
2002	12	61	27	100

North: Tarapacá, Antofagasta, Atacama, and Coquimbo; South: from Aconcagua to Ñuble, including Santiago; from Concepcion to Magallanes

entered all the data we were able to find during the period when we were given access to it. We argue, though, that our sample is representative of the whole population.⁶ In total, our refined sample contains 36,371 cases for the 1900s–1990s, around 3700 per decade on average, after deleting duplicated names or those outside our

⁶ To show that our sample of soldiers is representative of the whole population, we have compared its literacy and occupational structure to data from the national censuses. Our literacy data refers to the ability to sign only, which is a basic skill, while that available from the censuses refers to the ability to read (and from 1960 to read and write). Although both measures are not the same, a comparison shows that in our data, 88% of the sample was able to sign, while in the 1930 census, for example, 75% of the Chilean population older than 7 years was able to read. In the 1970 and 1982 censuses, this increases to 90% and 92%, respectively (for those older than 10 years). In this respect, our data are fairly representative of the whole country, as far as literacy is concerned. As for occupations, the information we found was not congruent with the jobs classification available in the censuses. Thus, we reclassified occupations from our data and the censuses into six broad categories: professionals; skilled workers; soldiers; students; technicians; and unskilled workers, as shown in “Appendix 2”. Based on these categories, we can conclude that our data are representative of the whole country for this variable too.

defined age range. From the filiation sheets, we were able to collect information on age, year of birth, year of filiation, height, skin colour, eye colour, hair colour, place of birth, military unit, military rank, literacy (ability to sign), and previous employment (if any). We also entered province and region of birth and classified localities of birth as urban or rural,⁷ as well as the population density of the region of birth.⁸

The sample of soldiers is representative of the lower socio-economic strata, thus accounting for the majority of the (male adult) population in Chile. In 1896, universal compulsory military service for the army was trialled, and 4 years later, when the army was restructured and the militias abolished, it was eventually enforced (Delgado 2015; Hernández 1984). From 1900 onwards, all soldiers accepted in the army were conscripts under compulsory universal conscription. This system remained in place until 2005 (i.e. most of our period of study).⁹ Thereafter, the annual quota needed by the Chilean army was first completed with voluntary enrolment. A total of 88% of our sample contains soldiers enrolled from 1917 to 2004, a period with compulsory enrolment and therefore unaffected by the selectivity issues highlighted by Bodenhorn et al. (2017).¹⁰ Volunteer soldiers enrolled under the new system (2005–2019) were soldiers mainly born during the 1980s and 1990s and represent only 12% of the sample. Were there to be any effect on our sample, we believe that volunteers would emerge as slightly shorter than the rest of the population (as wages in the market economy for unskilled workers were higher than in the army, in particular in a buoyant period for the economy). If that is the case, the increase in stature we are documenting could be an underestimation of the actual increase in the population. In our estimation, we considered restricting the sample to exclude these potential volunteers and the results do not affect our conclusion: adult male height increased during the twentieth century.

One problem commonly faced in anthropometric studies is the minimum height requirement (MHR) imposed by the armies. In the Chilean case, there was a MHR set at 160 cm (at least nominally) at the beginning of the period under study. This MHR was then lowered to 155 cm (we have not been able to state the exact year, but *c.*1931), once again increased, this time to 165 (around the mid-1950s), to be lowered to 160 cm in 1974. The sample could be truncated to the left, towards these MHRs, and would not have a normal distribution, as would be expected, for the entire population of a given country (Salvatore and Baten 1998; Komlos 2004). We then visually inspected the distribution of our sample, as recommended by Komlos and Kim (1990). Fortunately, Fig. 2 suggests that there are many observations below these MHR, and that there was no particular truncation at 155 or 160 cm (other than

⁷ We classified the locality of birth as either rural (less than 2000 people) or urban (2000 or over 2000 people), both according to the data from the closest census to the year of birth.

⁸ Population density per province was extracted from the national census closest to the year of birth.

⁹ <https://www.leychile.cl/Navegar?idNorma=241847&buscar=SERVICIO+MILITAR+OBLIGATORIO>.

¹⁰ Baten and Blum (2014) estimated that more than 90% of anthropometric studies have relied on conscript or anthropological (not "selective" volunteer or prison) data, as ours does.

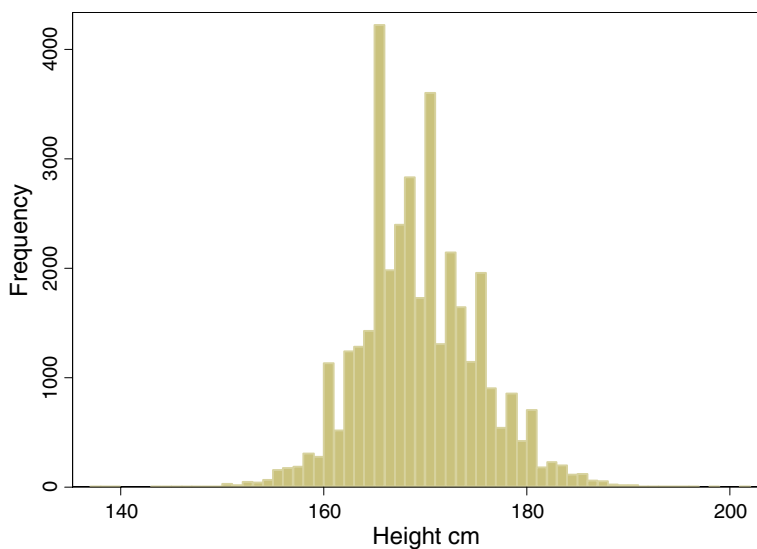


Fig. 2 Histogram, distribution of adult male height in Chile, 1900s–1990s (in centimetres, 36,371 observations)

the usual heaping).¹¹ Minimum heights by decade of enrolment do not show any particular truncation point either; all decades have observations below 155 cm.¹²

Another potential issue was heaping: an unusually high number of observations around rounded numbers (e.g. 165 cm or 170 cm). More often than not, the officials in charge of measuring new recruits were tempted to round numbers up to certain heights. It is also common to find unusual numbers of soldiers measuring exactly the MHR, which probably reflects false reporting in times of high demand (see Baten et al. 2009). We do have visual evidence of heaping at 165 cm in particular, but also at 170 cm and 175 cm, although this issue does not usually affect average heights for populations (Komlos 2004; Mokyr and O’Grada 1996).

Another potential issue was the age range to be used. People carry on growing until a certain age, maintain that height for several decades, and eventually start shrinking (from around 55 years old). Thus, when working with adults, it is important to avoid including in the sample people that are still growing or shrinking. Nowadays, it is believed that people grow until 17–18 years of age (Salvatore and Baten 1998). Thus, we have taken the 17–55 range, although we tested the 17–20 range, controlling by age in our regression analysis, as well as excluding soldiers aged 17–21 from the sample. Most of the soldiers in our sample were aged between 19 and 24 years old (76% of the whole sample), as shown in Fig. 3. Note that not all

¹¹ We also performed the same visual inspection per decade of birth, and the results were the same.

¹² However, in the empirical analysis we do consider the possibility of truncation at the highest MHR, 165 cm, as well as the most common MHR, 160 cm; results remain the same in both cases.

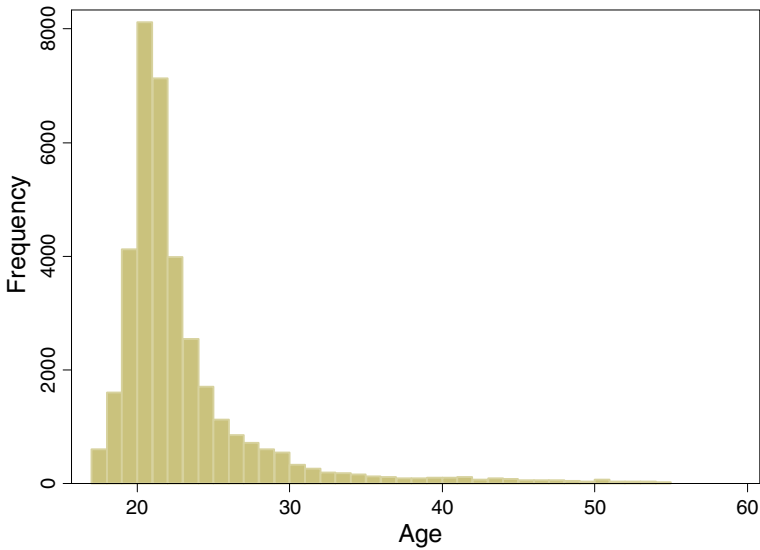


Fig. 3 Histogram, distribution of adult male age in the sample, 1900s–1990s (in years of age, 36,371 observations)

were recorded at their conscription age, since we also collected data from medical records and retirement files, besides the conscription records themselves.

4 Results

4.1 General results

Table 2 shows the raw average height of Chilean soldiers per birth decade, as well as the number of cases included in our dataset (soldiers aged between 17 and 55; in “Appendix 1”, we provided the same information but for ages between 20 and 55 only, revealing similar trends). For the entire period, 1900–1999, the raw average height was about 168.9 cm (with a standard deviation of 5.9 cm). There was a continuous growth between the 1900s and the 1990s, except for a mild decline in the 1940s (a decade characterised by higher population growth). As the average height was around 166 cm in the first decade of the century, and over 172 cm in the 1990s, we observed an increase of 6 cm over the century. As we shall show in the last section of this paper, the increase in height in Chile, although impressive, is in line (or lower) with that experienced by other countries.

Table 3 shows average height per skin and eye colour. On average, those classified as *trigueños* were the tallest soldiers, closely followed by whites. In our regressions, we formally tested the significance of these variables. Inequality in height per ethnicity appears to have been smaller in the twentieth century than in the eighteenth century (Llorca-Jaña et al. 2018a). The difference in height per ethnicity in Chile seems to have been smaller than it was in other Latin American countries for which

Table 2 Average raw height of Chilean soldiers per decade of birth

Decade of birth	Obs	Raw average	Min	Max	SD
1900s	3687	166.2	138.0	190.0	5.9
1910s	4068	167.0	145.0	191.0	5.4
1920s	2679	167.4	137.0	185.0	4.9
1930s	2257	168.5	144.0	190.0	5.1
1940s	3409	168.0	145.0	189.0	5.4
1950s	10,371	168.9	145.0	196.0	5.5
1960s	1689	170.4	151.0	195.0	5.5
1970s	2179	171.2	150.0	198.0	6.1
1980s	3804	171.9	148.0	202.0	6.0
1990s	2228	172.4	139.0	195.0	5.9
Total	36,371	168.9	137.0	202.0	5.9

Table 3 Raw average height per skin colour and eye colour, 1900s–1990s (and number of observations)

Skin colour/eyes colour	Blue	Brown	Gray	Black	<i>Pardos</i>	Green	Unavailable	Grand total
White	169.4	169.1	168.5	167.4	167.6	169.2	169.3	168.7
Dark (Moreno)	169.1	168.9	169.1	168.1	166.9	169.1	169.8	168.5
Trigueño	169.8	169.1	165.0	169.7	168.5	169.8	171.5	169.1
Black								
ND								
Total	169.3	168.9	168.7	168.0	167.2	169.2	171.7	168.9

Skin colour/eyes colour	Blue	Brown	Gray	Black	<i>Pardos</i>	Green	Unavailable	Grand total
White	250	5107	16	215	2157	1338	60	9143
Dark (Moreno)	48	15,803	18	1414	4237	699	411	22,630
Trigueño	16	353	1	20	159	97	2	648
Black		3		1	2		1	7
ND	1	14		5	12	1	3910	3943
Total	315	21,280	35	1655	6567	2135	4384	36,371

Pardos is a variant of brown, but with a reddish touch. We have grouped both categories in our regressions

there is comparable evidence (in particular if compared to Mexico, as shown by the works above listed for this country). Finally, soldiers who had blue and green eyes were also taller than the others, but the margin was small.¹³

¹³ Eye colour could be taken as another proxy for ethnicity. People with light-coloured eyes probably descended from emigrants from Northern Europe. A recent study shows that, on average, the prevalence of eye colour, either blue or green, in British, German, Danish, and Dutch people is 68%, 73%, 85%, 72%, respectively (Katsara and Nothnagel 2019), while in Chile, brown is the dominant eye colour. Thus, eye colour is another proxy to study the impact of ethnicity (measured through eye pigmentation) on height. Given the strong correlation between eye colour and skin colour, we only consider the latter in our empirical exercise.

Table 4 Raw average height per rank, 1900s–1990s

Military rank	Raw average height	Obs
Corporal	169.6	3972
Soldier	168.6	28,235
Sub-officer	168.5	424
Civil employee	168.4	86
Sergeant	168.2	916
Vice sergeant	167.6	103
Unavailable		2635
Grand total	168.9	36,371

Table 5 Raw average height per birthplace, per macro-region, 1900s–1990s

Region of birth	Obs	Share region (%)	Raw average
Centre	20,494	56	169.4
North	4152	11	168.5
South	11,622	32	168.3
Unavailable	103	0.3	168.9
Grand total	36,371	100	168.9

Table 4 shows raw average height per military rank, which can be regarded as a measure of social status, given the lack of alternative measures of socio-economic status (SES) in our sample. We have little information about the promotion of ordinary soldiers to the rank of either sergeant or corporal, but we can reasonably assume that better educated and able soldiers progressed quickly within the army. Corporals were the tallest of the sample, as they were nearly 170 cm tall, while ordinary soldiers were only slightly shorter than corporals (by circa 1 cm); sergeants and sub-officers were shorter, but similar in stature to ordinary soldiers. Since it is difficult to interpret the difference between corporals and sergeants, in the regression, we compared ordinary soldiers against all other categories. In any case, little difference in height was seen according to this alternative indicator of SES.

Table 5 contains raw average height per region of birth for the soldiers. We divided the geographical origins of the soldiers into three large areas, in line with the national census data: South, Centre, and North. Fifty-six per cent of our sample belonged to the Centre (roughly the same rate as the actual share of the censuses, at least for the first half of the century: see Table 1); 32% came from the South (in line with data from the national censuses); and 11% from the North (again, similar to the share of the censuses). The sample was effectively representative of the region of birth of the national population. Soldiers from the Centre were taller than the rest, and those from the South were the smallest.

4.2 Regression results

Next, we proceeded with regression analysis to estimate the mean height of the population, including each of the recorded characteristics documented above. As has often been noted, there are potential empirical problems when estimating means of population height from a sample of soldiers, in particular due to MHR that truncates the distribution of the population in the observed sample. Visual inspection of the histograms did not show any apparent truncation (Fig. 1); even histograms by decade of birth and decade of enrolment showed no sign of MHR being in place (results available upon request). The mean height and standard deviation by decade of birth (Table 2) also pointed to the absence of truncation in the sample. There was some heaping (at 160 cm, 165 cm, and 170 cm, for example), as is usually the case in these studies. We were confident enough in our sample to proceed with OLS regressions, but included also a truncated regression for comparison purposes.

Table 6 shows the conditional correlation of adult male height and soldiers' main characteristics. Columns 1, 2, and 5 include separate indicator variables for young soldiers, aged 17–20, as well as a single indicator variable for older soldiers, aged 50–55. All indicator variables captured shorter soldiers, those who were still growing, and older soldiers who might shrink. Columns 3 and 4 restrict the sample to soldiers aged 21 and above. Column 5 shows a truncated regression at the highest MHR, 165 cm.¹⁴

We included indicator variables for *moreno* (dark skin) and *trigueño*; the excluded category was white and those who did not report skin colour. We included an indicator variable for army members ranked as ordinary soldiers in columns 2, 4, and 5. Columns 1–5 show a negative and significant correlation between dark skinned soldiers and height. We also considered the region of birth and divided the country into three distinctive macro-regions: North (the excluded category), Central, and South. Indicator variables for soldiers coming from central areas show a positive correlation with adult height, with an estimated coefficient of about 0.65 cm. Soldiers coming from the South were consistently shorter (when compared to soldiers from the North); we estimated a negative and significant coefficient of around 0.5 cm.

Lower-ranked members of the army, soldiers, usually came from lower social strata. Columns 2, 4, and 5 in Table 6 show that *soldiers* have a negative and significant coefficient of around 1.5 cm (i.e. shorter heights for lower-ranked soldiers, in comparison with higher-ranked soldiers).

Soldiers who came from rural areas negatively correlated with height; they were close to 1 cm shorter than soldiers who came from urban areas. The rural *penalty* may seem at odds with the experience of some developed countries, but it does accord with the experience of other Latin American countries such as Colombia (Meisel and Vega 2007) and Argentina (Salvatore 2007). It is also consistent with the idea that modern societies have been increasingly and successfully managing urban disamenities so that rural health is nowadays (most of the time) inferior to

¹⁴ We ran a similar regression with the most *common* MHR, 160 cm, and results remained the same (results upon request).

Table 6 Conditional correlations of adult male height

Dependent variable: height in cm	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	Truncated Reg.
Sample	All	All	Age > 21	Age > 21	MHR 165
Skin colour: Moreno	-1.047*** (0.0649)	-0.671*** (0.0666)	-1.033*** (0.0850)	-0.777*** (0.0852)	-0.741*** (0.111)
Skin colour: Triguëño	-0.557** (0.228)	-0.103 (0.230)	-0.329 (0.302)	0.0262 (0.304)	0.312 (0.388)
Rural	-0.827*** (0.0720)	-0.791*** (0.0715)	-0.787*** (0.0868)	-0.739*** (0.0864)	-0.908*** (0.130)
Region: Centre	0.641*** (0.0954)	0.632*** (0.0950)	0.716*** (0.117)	0.713*** (0.117)	0.903*** (0.170)
Region: South	-0.407*** (0.100)	-0.389*** (0.100)	-0.413*** (0.124)	-0.399*** (0.123)	-0.260 (0.184)
Low-rank soldier		-1.520*** (0.0780)		-1.408*** (0.0964)	-1.663*** (0.124)
Age dummy 17	0.308 (0.242)	0.616** (0.242)			0.794** (0.401)
Age dummy 18	1.238*** (0.154)	1.435*** (0.153)			1.565*** (0.238)
Age dummy 19	1.613*** (0.0998)	1.682*** (0.0992)			1.519*** (0.155)
Age dummy 20	1.218*** (0.0754)	1.272*** (0.0750)			1.034*** (0.126)
Age dummy 50–55	-0.655* (0.365)	-1.531*** (0.366)	-0.649* (0.366)	-1.455*** (0.367)	-0.551 (0.688)
Constant	169.0*** (0.104)	169.9*** (0.114)	169.0*** (0.126)	169.9*** (0.141)	170.1*** (0.202)
Observations	36,371	36,371	21,911	21,911	25,216
R ²	0.034	0.045	0.019	0.030	–

OLS regressions. Region dummies are defined as South, Central Valley, and North (reference category). Skin colour is defined as *Moreno*, *Triguëño*, and white (reference category). Columns 1, 2, and 5 include indicator variables for young soldiers (aged 17–20) and older soldiers (age 50–55). Columns 3 and 4 restrict the sample to soldiers aged 21 and older. Columns 2, 4, and 5 include an indicator variable for army members ranked as ordinary soldiers. Column 5 considers a truncated regression at the highest MHR, 165 cm. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

urban health. We also considered an alternative specification in which population density is included (results upon request), and we estimated positive correlation between soldiers' height and population density.

Next, we examined the increase or decrease in adult height over the twentieth century. We included in our regression analysis a full set of decades of birth fixed effects. We defined nine indicator variables, one for each decade of birth (1910s,

Table 7 Height change over time

Dependent variable: height in cm	(1)	(2)	(3)	(4)	(5)	(6)
Sample	All	All	Age > 21	All	All	All
<i>Birth decade</i>						
1910	0.771*** (0.128)	0.832*** (0.129)	0.998*** (0.139)	0.887*** (0.164)	0.926*** (0.138)	1.238*** (0.356)
1920	1.185*** (0.135)	1.238*** (0.136)	1.254*** (0.147)	1.358*** (0.172)	1.191*** (0.146)	1.019*** (0.323)
1930	2.287*** (0.145)	2.336*** (0.146)	2.287*** (0.164)	2.550*** (0.179)	2.218*** (0.164)	2.467*** (0.349)
1940	1.840*** (0.136)	1.885*** (0.137)	1.817*** (0.160)	2.115*** (0.163)	1.751*** (0.160)	1.930*** (0.306)
1950	2.769*** (0.115)	2.816*** (0.116)	2.831*** (0.129)	3.094*** (0.141)	2.739*** (0.128)	1.978*** (0.252)
1960	4.129*** (0.169)	4.162*** (0.169)	4.176*** (0.214)	4.312*** (0.189)	4.108*** (0.213)	3.415*** (0.412)
1970	4.956*** (0.165)	4.944*** (0.165)	4.896*** (0.215)	5.238*** (0.188)	4.900*** (0.215)	4.263*** (0.294)
1980	5.547*** (0.143)	5.493*** (0.144)	5.168*** (0.200)	5.752*** (0.167)	5.318*** (0.198)	4.542*** (0.226)
1990	5.811*** (0.171)	5.595*** (0.182)	5.219*** (0.288)	5.766*** (0.203)	5.512*** (0.284)	5.131*** (0.217)
Rural	-0.244*** (0.0709)	-0.241*** (0.0709)	-0.142* (0.0858)	0.285 (0.197)	-0.242*** (0.0709)	-0.221*** (0.0709)
Rank: soldier		-0.297*** (0.0886)	-0.604*** (0.103)	-0.313*** (0.0887)	-0.318*** (0.0898)	-0.990*** (0.202)
Age 17–20					-0.567 (0.359)	
Interactions: decade of birth*				Interaction		
				Rural	Age 17–20	Soldier
1910*				-0.122 (0.262)	0.0159 (0.420)	-0.260 (0.385)
1920*				-0.291 (0.277)	0.709* (0.428)	0.412 (0.358)
1930*				-0.571* (0.306)	0.957** (0.428)	0.0222 (0.386)
1940*				-0.657** (0.300)	0.919** (0.404)	0.130 (0.343)
1950*				-0.982*** (0.243)	0.768** (0.374)	1.124*** (0.284)
1960*				0.103 (0.529)	0.718 (0.448)	1.047** (0.451)
1970*				-1.186*** (0.436)	0.690 (0.443)	1.020*** (0.353)
1980*				-0.881*** (0.332)	0.890** (0.415)	1.563*** (0.285)

Table 7 (continued)

Interactions: decade of birth*	Interaction					
				Rural	Age 17–20	Soldier
1990*				–0.423 (0.402)	0.725 (0.464)	0.826 (1.583)
Constant	166.6*** (0.134)	166.8*** (0.144)	167.1*** (0.164)	166.6*** (0.160)	166.8*** (0.147)	167.3*** (0.189)
Observations	36,371	36,371	21,911	36,371	36,371	36,371
R ²	0.110	0.110	0.095	0.111	0.111	0.112

OLS regressions. Decade of birth is defined as 1900 (the reference category), 1910, 1920, 1930, 1940, 1950, 1960, 1970, 1980, 1990. Region dummies are defined as South, Central Valley, and North (reference category). Skin colour is defined as *Moreno*, *Trigueño*, and white (reference category). All columns include indicator variables for young soldiers (aged 17–20), older soldiers (age 50–55), and rural. Column 3 restricts the sample to soldiers aged 21 and older. Columns 3–5 include an interaction term between decade of birth and rural, age 17–20, and rank = soldier, respectively. Columns 2–6 include indicator variable for army members ranked as ordinary soldiers. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

1920s, 1930s, 1940s, 1950s, 1960s, 1970s, 1980s, and 1990s), and left the 1900s as the reference category. Each indicator variable assigned a value of 1 if an individual was born in that decade, and 0 otherwise.

Table 7 presents our estimation results. We included the same control variables in each column as in Table 6. In columns 1–6, all decades of birth indicator variables were positive and significant. Moreover, the coefficients showed a steady increase in adult height over the twentieth century. Soldiers born in the 1910s were (on average) 0.8 cm taller than soldiers born in the 1900s. Soldiers born in the 1920s were 1.2 cm taller than soldiers born in the 1900s. By the end of the century, soldiers were close to 5.5 cm taller than soldiers born at the beginning of the twentieth century.

As in the previous table, soldiers coming from the South or dark-skinned soldiers were slightly shorter (results not shown in the table). Although in Table 6, members of the army ranked as soldiers were close to 1.5 cm shorter than others, in Table 7, this difference went down to 0.3 cm.

Columns 4, 5, and 6 in Table 7 include interaction terms between decade of birth and *rural*, *age 17–20*, and rank = *soldier*, respectively. These interaction terms allow us to distinguish any change in the association between the variable and the outcome variable over the decade of birth. Column 4 shows the interaction between decade of birth and rural; the coefficients on the interaction term show an increasing negative correlation over time, so that by the end of the twentieth century, men from rural areas were close to 1 cm shorter than those from urban environments.¹⁵ Column 5 shows the interaction between decade of birth and age 17–20 (soldiers aged 17–20);

¹⁵ To analyse regional differences in the rural *penalty*, we ran a different specification, similar to Table 7 column 2, where we included interaction terms between rural areas and the regions. The results showed soldiers coming from rural areas in the Northern regions were shorter than all other soldiers. No (statistically significant) difference was found among soldiers from Southern regions (results upon request).

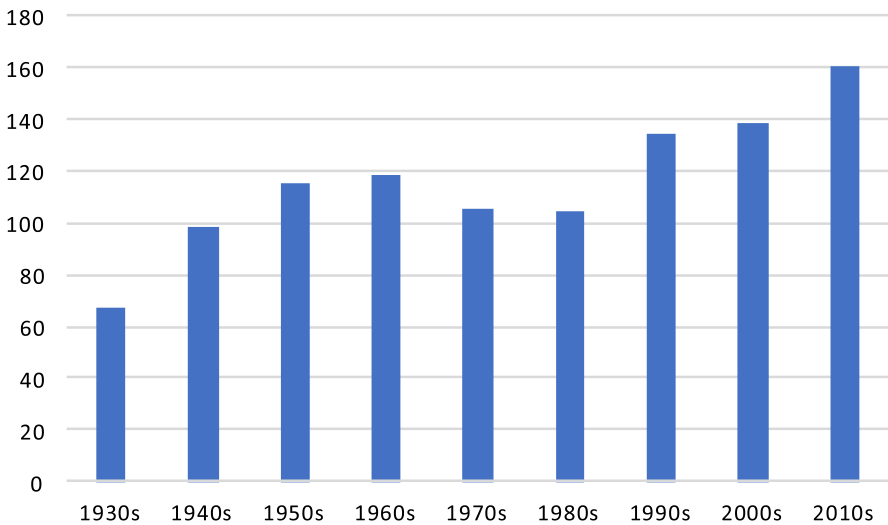


Fig. 4 Chilean per capita consumption of dairy products (litres per person per annum, yearly averages per decade). *Source:* Llorca-Jaña et al. (2020b)

the interaction coefficients show no clear relationship over time. Finally, column 6 shows the interaction between decade of birth and army members ranked as soldiers. Taking into account the preceding discussion on rank as a measure of social and economic status, we observed an increase in height towards the end of the twentieth century. As mentioned below, other determinants explain the secular increase in height, in particular for lower socio-economic groups.¹⁶

5 Other determinants of height in twentieth-century Chile

Beyond the variables analysed in our preceding tables (restricted to the information available in military records), many other developments merit consideration, since they may have affected height in Chile during our period of study. First, two key foods are known to be determinants of human height: dairy products and meat [see Baten (2009) for milk in particular]. We gathered sound continuous data on annual national consumption of milk from the 1930s to the 1990s (Fig. 4), and patchy data for earlier years, to produce the first series on milk consumption in Chile. At the beginning of the century, Chile managed to produce small quantities of milk for human consumption. A report written in the 1930s estimated that Chileans' consumption of milk was about 30 L per person per annum short of the minimum recommended intake, on account of the lack of supply in the country (Torres 1938). Milk processing in industrial plants was in its infancy, and even posed a threat to human consumption

¹⁶ We also considered interaction terms between decade of birth, skin colour, and region, respectively. We found no clear result (results upon request).

(Deichler 2016; Cruz-Coke 1928; González 1935). It was estimated that in 1917 and 1930, the country consumed 51 and 65 L of fresh milk equivalent per person annually, respectively. In comparison, in per capita averages, most European countries at that time produced and consumed far more milk than Chile (Allende 1939).¹⁷ At the beginning of the century, the diet of most Chileans was lacking in calcium; otherwise, the increase in stature would have been higher during the 1900s–1930s.

Child malnutrition led to the so-called milk problem in Chile during the first decades of the twentieth century, on account of its scarcity, poor quality, high price, and low consumption (Goldsmith 2017). In time, public policies managed partially to revert this situation. In the 1930s, the government issued a law to promote milk pasteurization, and by the late 1940s, the country was already consuming over 100 L of fresh milk equivalent per person per year. Milk consumption increased significantly during the 1950s and 1960s, in part due to government policies to promote milk consumption in schools, which were implemented thanks to the government's greater intervention in the economy during the so-called ISI period. Milk (mainly powdered, but also condensed) was also distributed in public health institutions along with advice on preventive health care (Goldsmith 2017). Stagnation and decline during the 1970s–1980s (when unemployment was high), were followed by an increase in consumption during the 1990s–2000s–2010s, to eventually reach the equivalent of 160 L per person per annum in the 2010s, over twice as much as in the 1930s. This is the level of per capita consumption recommended by the World Health Organization (Fedeleche 2013). The sustained economic growth of the country (together with higher real wages) from the late 1980s helped to achieve this intake of dairy products, along with high income elasticity of the demand for dairy products.

Beyond demand for milk, the driving force behind this dramatic increase in per capita consumption of dairy products during the last three decades has been the national production of milk, rather than foreign trade (i.e. imports): production increased from around 0.9 million litres per annum during the 1970s to over 2.25 million litres during the last decade. Net imports (imports minus exports) were more important between the 1950s and early 1990s than thereafter, since the country started to export increasing quantities of dairy products from the mid-1990s, providing a counterbalance to imported dairy products.

The consumption of meat in the early twentieth century in Chile was also limited on account of the high prices in the retail markets (González 1935).¹⁸ The lower socio-economic strata of the population ate a diet dominated by wheat-based products, such as bread (Núñez and Pérez 2015; Santa María 1935). The intake of animal proteins was less than half of the equivalent level during the late colonial era. This situation led to a famous “Meat Strike” in 1905 and the “Hunger Riot” of 1919, both triggered by the prohibitive price of meat for the labouring class.¹⁹

¹⁷ This level of milk consumption was less than half of the level recommended by the League of Nations Committee (Scriggie 1942).

¹⁸ In 1910, there were 2.3 million heads of cattle in Chile, or 0.7 per person, with the country ranking 14th within Latin America. In Uruguay, Paraguay, and Argentina, the comparable figure was 10.0, 6.8, and 4.3 heads of cattle per person, respectively.

¹⁹ There was a similar situation in Mexico during the *Porfiriato* (López-Alonso 2015).

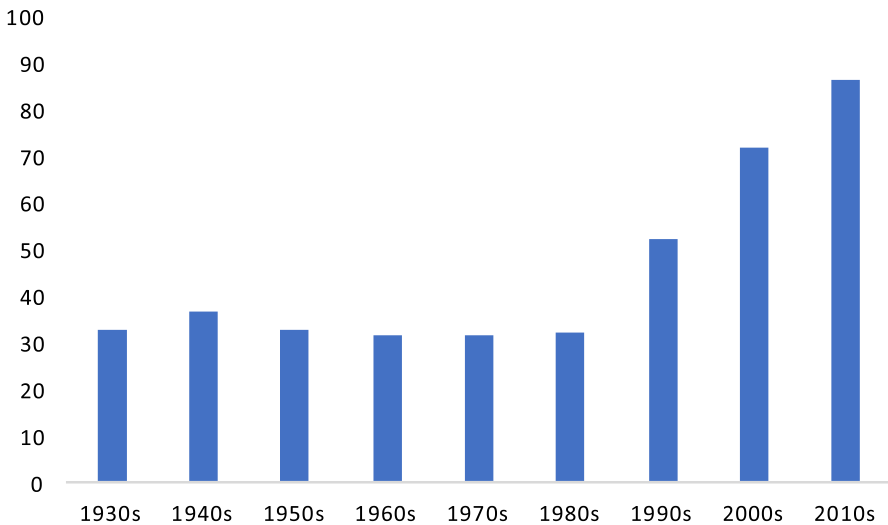


Fig. 5 Chilean per capita consumption of meat (ready-to-cook kilograms per year). *Source:* Llorca-Jaña et al. (2020b)

Figure 5 presents new data on meat intake, which includes beef, chicken, pork, ovine, and equine meats. Per capita meat consumption stagnated between the 1930s and 1980s, with an annual consumption of 31–33 kg per capita per annum only (except for the 1940s when it was slightly higher). It increased dramatically from the 1990s onwards. These were golden decades for the Chilean economy, when the country achieved its highest real wages ever [Fig. 9, see also Moreno (2017)] and the fastest growth of GDP per capita (Fig. 2). Chileans are now consuming over 90 kg of meat per annum (more than 100 kg if fish and seafood are included), on average, an amount that falls within the levels recorded by FAO for developed countries, and doubles the world average (Nierenberg 2005). Chile has reached a level of meat consumption that can hardly be increased, at a time when its male population reached its highest ever physical stature.

The rise in meat consumption can be associated with Chile joining the international agribusiness revolution, which impacted heavily on meat production worldwide, in particular the production of pork and chicken produced in industrial plants (the supply side of the story).²⁰ “Red” meats are now generally more popular than “white” meats. Cheap chicken and low-priced pork meat led to a revolution in the Chilean diet as lower prices combined with high income elasticity of demand, as in most developing countries (Aho 2002). Per capita consumption of chicken increased more than 20-fold between the 1930s and the 2010s, while that of pork increased some 400% in the same period.

²⁰ Between 1950 and 2005, global meat production increased more than fivefold, with pork, followed by chicken, leading the way (Nierenberg 2005).

The increase in height of the Chilean population during the last three decades is not surprising, given the increasing consumption of milk and meat. *Ceteris paribus*, during the 1990s–2010s, increases in height were due to a better diet, combined with better income distribution (at least during the 1990s), universal health care and education. But how to account for the continuous growth during the previous decades?

The answer lies in the 1930s–1960s and the 1970s–1980s. During the 1940s–1960s in particular, real wages were increasing, as well as milk consumption. The state intervened in economic affairs, providing cheap energy (i.e. gas) for urban households, as well as electricity. While during the 1910s–1920s, there was increasing inequality (otherwise, height would have increased even more), during most of the 1930s–1960s, income inequality decreased (Rodríguez 2017; Arellano 1985).²¹ The 1960s were particularly good for real wages (Moreno 2017). Social policies multiplied until the military coup of 1973, improving the biological welfare of the population, including social protection schemes in what was akin to a welfare state. For these decades, it is reasonable to assume that increasing height was more due to effective social policies impacting on health and education than to better diet. A similar argument has already been made by Núñez and Pérez (2015) when explaining the increase in height of boys of lower socio-economic status in Chile during this period. Since Chile experienced moderated economic growth, increases in these boys' height ought to be explained by social policies improving health, and living conditions.

These policies were translated into better biological welfare for most of the population. Personal hygiene and safe food-handling both improved. There were several government information campaigns to provide dietary advice, in particular for children and pregnant women, and to promote industrialised foods, which were highlighted as less prone to decomposition at a time when refrigeration systems, domestic, and commercial were neither as efficient nor common as nowadays. National campaigns also disseminated information about the nutritional character of recommended foods (Scriggie 1942; Zárate 2013; Deichler 2016).²²

In the first decade of the twentieth century, when height was at its lowest, an outbreak of typhoid fever took 25,000 lives between 1905 and 1910. Antibiotics were subsequently introduced into the public health service (penicillin in particular was widely adopted), as well as compulsory vaccines from the 1930s, as part of an international movement²³ (Zárate 2013; Steckel 1995). In the 1890s, there were nearly 35 thousand deaths for smallpox; in the 1930s, this number was down to less than

²¹ The slight decrease in raw average height in the 1940s (Table 2) may be due to population growth that decade, which was higher than in the preceding three decades. This factor could have put pressure on food distribution. There were also many earthquakes during this decade, in 1942, 1943, 1945, 1948, and 1949, affecting several regions of the country.

²² Dietary habits were seen as crucial to improve the health of families, since it was rightly believed that digestive problems were one of the main causes negatively impacting child mortality. Thus, there were many programs to educate people on these topics (Deichler 2016). It was estimated that in 1893, 40% of all deaths in Chile were due to problems with the digestive system (Sierra and Moore 1895).

²³ However, for a while, vaccination was neither compulsory nor universal, which explains why some epidemics took place. Nonetheless, in the 1890 s, the average annual vaccination was 448 thousand; in the 1920s, it was already nearly 1.5 million (Salinas 1983).

12 thousand (Salinas 1983). The first child hospitals were also built in the country around this time, and the study of paediatrics was encouraged in Chile (Deichler 2016). There was also a continuous increase in the number of medical doctors and other professionals employed by the health sector, resulting in the professionalization of the medicine in Chile,²⁴ and the emergence of preventive medicine programs from 1938 onwards (Núñez and Pérez 2015). As part of this process, health was no longer the private concern of individuals, who were usually reliant on limited charitable funds, but a collective and public matter, with the state providing almost universal coverage, and a strong emphasis on prevention (Illanes 1993; Zárate 2008; Monckeberg et al. 1987).²⁵ This development had wider implications. During the first decades of the twentieth century, the campaign against malnutrition in Chile was the preserve of a charitable institution (Patronato Nacional de la Infancia), until Pedro Aguirre Cerda's government started to provide breakfast in public schools (Moreno 2017).²⁶ As a result of better health, among other factors, life expectancy increased dramatically in Chile (Fig. 6), from the 1930s, and most significantly from the 1950s onwards, from around 30 years at the beginning of the century to 77 during the 1990s, and comparable to developed countries (Núñez and Pérez 2015). Maternity leave was extended to 90 days in 1959, to promote breast-feeding (Monckeberg et al. 1987). These early health improvements from the 1930s, combined with a decrease in income inequality (and low population growth), may explain why stature increased during the 1930s despite the economic downturn affecting the country. Furthermore, a recent study (Rivero et al. 2020) has shown that the negative impact of the Great Depression on the nitrate industry during the 1930s had been exaggerated in the literature.

In common with most other Latin American countries (López-Alonso 2015), Chile experienced the so-called mortality revolution, with an improvement in child mortality in particular. Child mortality in 1907–1909 was around 285 per thousand births (for infants younger than 12 months),²⁷ falling dramatically from the 1940s to less than 100 during the 1960s, to slightly over 20 during the 1980s and to 12 during

²⁴ It was estimated that in 1854, there were only 129 medical doctors in Chile, one for every 12,000 inhabitants. This ratio improved to 1 per 3300 inhabitants in 1895, 1 per 1870 inhabitants in 1940, 1 per 983 inhabitants in 1992, reaching 1 for every 646 inhabitants in 2007 (Zárate 2007). In 1865, there were only 29 hospitals in Chile, while in 1950, there were already 178 (Salinas 1983).

²⁵ In 1924, the Ministry of Hygiene, Work, and Pensions was established. The National Health Service was created in 1952, taking over several institutions already in existence and was considered to be a landmark in Chilean health history. For the first time, medical care was centralised in Chile, and in public ownership. Coverage was universal, and after a few decades, the Chilean population started to enjoy some basic services already available in more developed countries, which resulted in an improvement in many health indicators such as life expectancy and child mortality. Chile became a pioneer in medical care within Latin America (Moreno 2017; Illanes 1993; Núñez and Pérez 2015; Arellano 1985).

²⁶ In 1938, the Mother & Son Law was passed; this granted universal medical care to all children under 2 years, as well as access to milk, although it had only reached 10% of the population by 1950 (Moreno 2017; Goldsmith 2017).

²⁷ This was one of the highest rates in the world (Deichler 2016), leading to the creation of the *Patronato Nacional de la Infancia* (Deichler 2016).

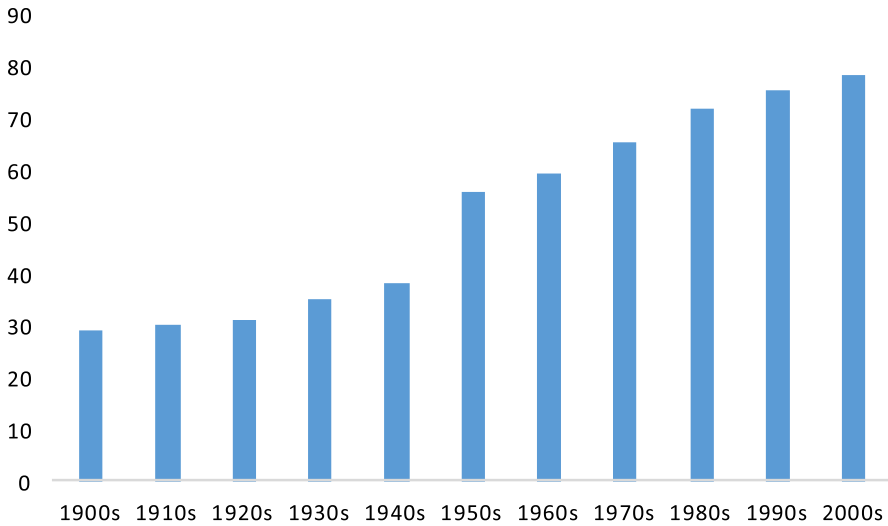


Fig. 6 Life expectancy at birth in Chile (in years). *Source:* Own elaboration from Díaz et al. (2016)

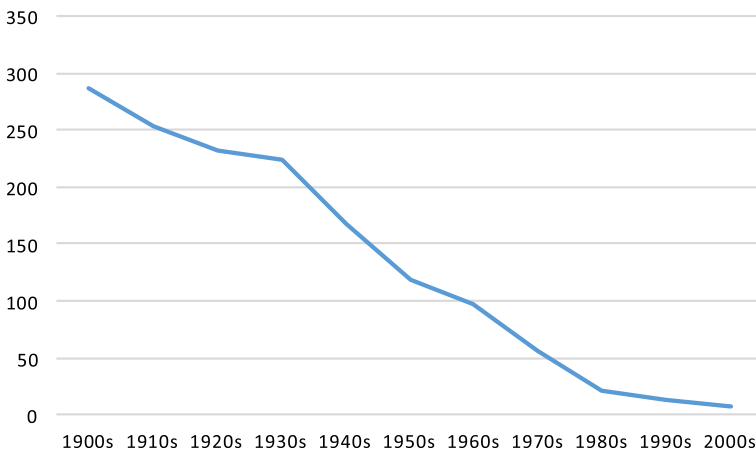


Fig. 7 Child mortality (in infants younger than 12 months) in Chile, average per decade (deaths per thousand births). *Source:* Own elaboration from Díaz et al. (2016)

the 1990s (Fig. 7). This was a remarkable achievement for a middle-income country. The epidemiological transition²⁸ of Chile also took place during the 1930s–1960s.

The national coverage of drinking water services, sewerage facilities, and electricity also increased dramatically, particularly after the 1960s, largely due to the introduction of modern technologies in the civil engineering sector (Arellano 1985).²⁹ It

²⁸ The process by which the pattern of mortality and morbidity is transformed from one of high mortality among children (due to infectious diseases) and episodic famine and epidemic affecting the entire population to one of the degenerative and man-made diseases affecting principally the elderly.

²⁹ There was a similar situation in other countries of the region, such as Mexico (López-Alonso 2015).

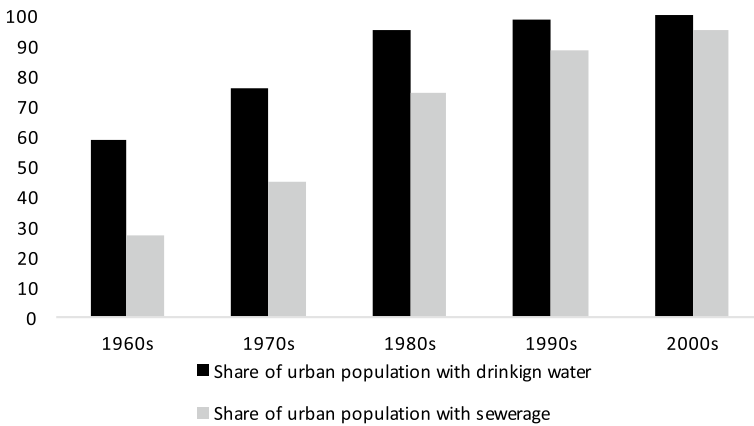


Fig. 8 Urban coverage of drinking water and sewerage, 1960s onwards. *Source:* Own elaboration from Díaz et al. (2016)

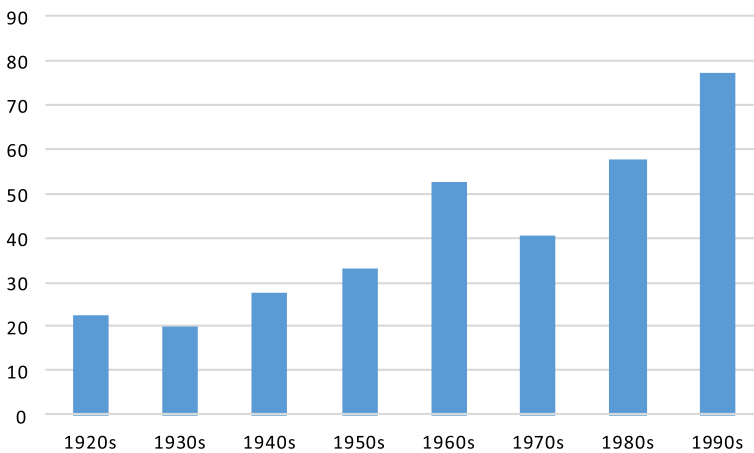


Fig. 9 Chilean index of real salaries (2003 = 100), annual averages per decade. *Source:* Díaz et al. (2016)

was estimated that in 1930, less than 40% of the Chilean population enjoyed both drinking water services and sewerage (Allende 1939). Yet, in the 1970s, three-quarters of the urban population enjoyed drinking water facilities and nearly half had sewerage facilities, at a time when urbanization was on the increase (Fig. 8). By the 1990s, the national coverage for these two services was nearly universal. This is important because these are many of the factors that explain the growth in the global increase in stature (Steckel 1995).

National education was also a factor. Fifty per cent of the population was illiterate at the beginning of the twentieth century, but just 5% during the 1990s, while the average time spent in school increased from slightly more than 2 years to over 9 years in the same period (Díaz et al. 2016). There was almost universal attendance at primary school by the early 1970s, which was combined with effective food programs for children attending public schools, in particular from the 1950s (Núñez

and Pérez 2015). The Human Capital Index more than doubled its value between the 1900s and the 1990s (Díaz et al. 2016). These factors support Núñez and Pérez (2015)'s hypothesis that the substantial and steady increase in public social expenditure observed in Chile during the second half of the twentieth century (including social public expenditure as a fraction of GDP) improved the biological welfare of the population.

Real wages (Fig. 9), milk and meat consumption, and income distribution were all low in the 1970s–1980s (Rodríguez 2017). Yet height, and other indicators of living standards, continued improving, which may appear surprising (see also Moreno 2017). Earnings decreased dramatically in the 1970s, although the 1980s witnessed a recovery. Why did height increase?

Our previous data confirm a continuing improvement during the 1970s–1980s in child mortality, life expectancy, increasing coverage of drinking water services and sewerage facilities, which would explain the upward trend in height. Furthermore, the 1970s were free from natural disaster and significant earthquakes, while the rate of population growth decreased markedly. Other indicators also show important improvements. In 1960, only 52% of births were technically assisted in Chile; in 1990, this ratio had increased to 99.4%. Vaccination rates also increased from 60 to 96% in the same period, greatly reducing the incidence of diseases such as measles, whooping cough, and poliomyelitis (Monckeberg et al. 1987; Moreno 2017; Raczynski and Oyarzo 1981). A recent study for Chile covering the 1960s–1980s, which analysed the relationship between adult height and early-life exposure to disease exclusively, found that the drop in infant mortality rates during these decades explained almost all of the long-term trend in rising adult heights, and that GDP per capita does not appear to have any predictive power (Borrescio-Higa et al. 2019).³⁰

The decrease in child mortality during the 1970s and 1980s was the highest in Chilean history (Díaz et al. 2016): child mortality in the 1980s was 25% lower than in the 1960s. Malnutrition rates among children younger than 6 also fell dramatically from 37% in 1960 to 19.3% in 1970, to 11.5% in the late 1970s, and to 8% in the late 1980s, despite the fluctuation in real wages (Moreno 2017). The combined fiscal expenditure on health and education as a share of GDP remained at respectable levels during the 1970s–1980s, and higher than during the 1900s–1950s (Moreno 2017). During Pinochet's dictatorship (1973–1990), despite the fall in wages during most of this period, social assistance was concentrated on the poorest strata of society ("extreme focalization" on the poorest), and in particular on those suffering malnutrition, mothers of recently born babies, and pregnant women. Overall expenditure in the health sector may have declined or stagnated, in particular new investments and real wages of those employed in the health sector, but the expenditure in goods and services (including milk) increased (Monckeberg et al. 1987; Raczynski and Oyarzo 1981). For example, powdered milk continued to be distributed free of charge (and with the fat content increased from 12 to 26%). There was a significant fall in the number of children dying from respiratory and diarrheal disease

³⁰ Both infant mortality and height are health proxies, and the direction of causality is not clear. We are grateful to one of this journal's referees for this point.

and the rate of low birth weight nearly halved, while malnutrition rates declined heavily (Monckeberg et al. 1987; Moreno 2017; Raczynski and Oyarzo 1981).³¹

Fertility also declined in Chile from the mid-1960s, but in particular during the 1970s, including the fertility of families of lower socio-economic status.³² These families could now distribute their income among fewer people, therefore increasing the per capita intake of protein. The fall in the birth rate has been signalled as one of the main factors behind the above-mentioned fall in child mortality (Monckeberg et al. 1987).

Modernisation within households, characterised by the increasing use of home appliances such as refrigerators and gas stoves, greatly improved food preservation and cooking. The consumption of these products was boosted by the reduction in import duties from the 1970s, since these were mainly imported goods, and their final prices were now declining (Llorca-Jaña 2015). The increase in physical stature in Mexico (López-Alonso 2015) and Chile during the 1970s–1980s was probably more closely linked to improvements in health, hygiene, and education, than to better nutrition or real income. Challú and Silva-Castañeda (2016), in a study concerned with female height during the second half of the twentieth century, were also struck by the fact that there was no increase in height during the boom years of the 1950s–1960s, nor was there a decrease during the gloomy 1980s, a lost decade for the region in macroeconomic terms.

6 Comparisons with other countries

The height of Chilean adult males increased by around 5–6 cm between the 1900s and the 1990s, but how does this compare with other countries? The short answer is that Chile did not do any better than most countries for which there is available data. Figures 10, 11 and 12 illustrate this fact. The difference in adult male stature between Chile and the USA, the UK, the Netherlands, and Sweden increased during this period. For instance, in the 1900s, Chileans were shorter by less than 5 cm than the Dutch, but by the 1980s, this gap increased to over 11 cm. In the same period, the difference between Chile and the USA nearly doubled in cm. More dramatic is the comparison with Spain. During the colonial period (Llorca-Jaña et al. 2018a), the nineteenth and twentieth centuries, Chileans were taller than the Spanish by about 1.5 cm, but by the 1980s, they were shorter by over 4 cm (Fig. 10). This development coincided with the change in the average height of women in Latin America (including Chile): it increased during the second half of the twentieth century but by a smaller margin than in developed countries (Challú and Silva-Castañeda 2016).

Compared to neighbouring countries in Latin America, Chile's performance was negative, but not significantly so (Fig. 11). The difference between Chile and

³¹ Because of the fall in fertility rates, new births received more attention, in per capita terms, than at other times (Raczynski and Oyarzo 1981).

³² An increase in the share of births from mothers with medium and high levels of education was also observed (Raczynski and Oyarzo 1981).

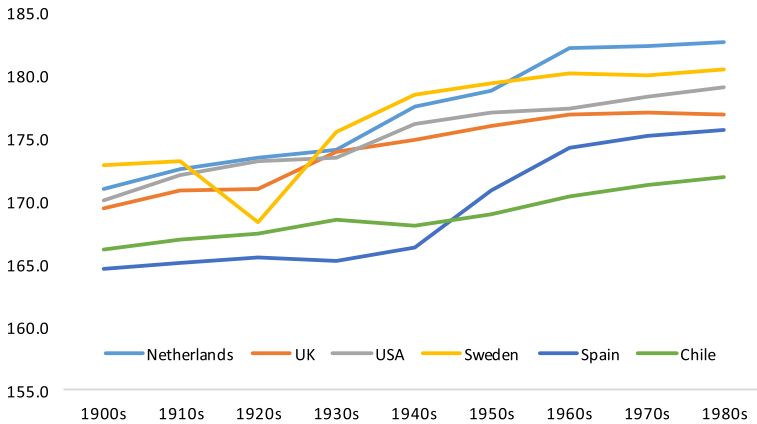


Fig. 10 Height in Chile and more developed countries, 1900s–1980s (adult males). *Source:* Chile, our data; Baten and Blum (2012) for all others, available at Clio-Infra project (<https://clio-infra.eu/>). In turn, Baten and Blum (2012) relied mainly on Costa and Steckel (1997) and Komlos (2009) for the USA; on Floud (1994), Van Wieringen (1972), Eurobarometer (1996) and Hatton and Bray (2010) for the Netherlands; on Sandberg and Steckel (1997), Hatton (2009) and Silvertoinen et al. (2001) for Sweden; Kemsley (1951), Clements and Pickett (1957), Hatton (2009), Rosenbaum (1988) and Eurobarometer (1996) for the UK; and on Martínez-Carrión and Pérez-Castejón (1998), Quiroga (1998) and Hatton (2009) for Spain

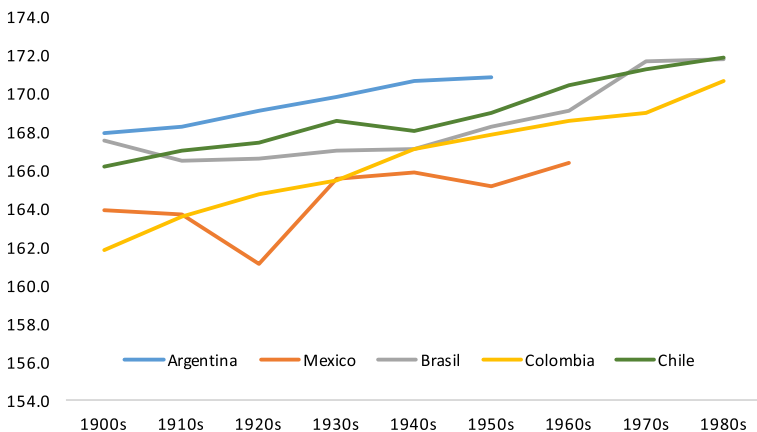


Fig. 11 Height in Chile and other Latin American countries, 1900s–1980s. *Source:* Chile, our data; Baten and Blum (2012) for all others, available at Clio-Infra project (<https://clio-infra.eu/>). In turn, Baten and Blum (2012) relied mainly on Salvatore (2007) for Argentina; López-Alonso and Porrás-Condey (2003) for Mexico; Meisel and Vega (2007) for Colombia; and Baten et al. (2009) for Brazil

Argentina for the 1900s–1950s does not show any clear trend, as the physical stature of Chilean adult males was below that of Argentina for the entire period. Chile improved its position relative to Mexico, although the margin was slight. For most of the century, Chileans were taller than Brazilians, until the 1970s–1980s, when Brazil overtook Chile. Colombia improved its relative height with respect to Chile, and the two countries converged during the 1940s–1950s. During the twentieth

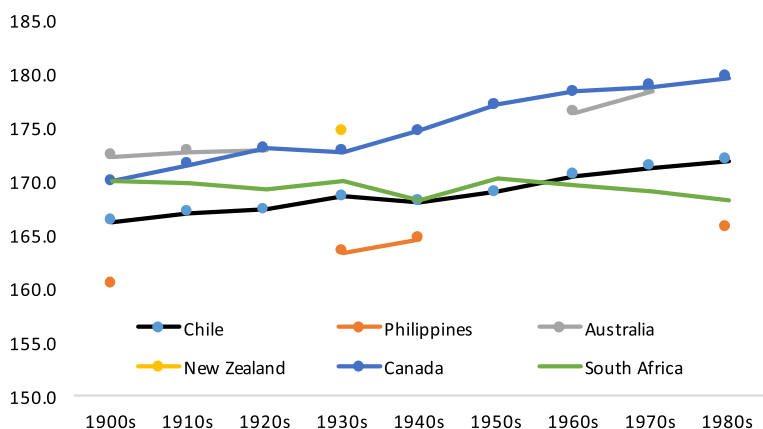


Fig. 12 Height in Chile and other primary producer countries, 1900s–1980s (adult males). *Source:* Chile, our data; Baten and Blum (2012) for all others, available at Clio-Infra project (<https://clio-infra.eu/>). In turn, Baten and Blum (2012) relied mainly on Meredith (1971) and data by WHO/UNESCO for Philippines; for Australia on Whitwell et al. (1997) and Australian Bureau of Statistics (1998); for New Zealand on Inwood et al. (2010) and Meredith (1971); for Canada on Cranfield and Inwood (2007); and for South Africa on Laing (1964), Crayen (2006) and Hiernaux (1968)

century, most Latin American countries diverged in height compared to most developed countries, and Chile was no exception.

Finally, it is also important to compare the Chilean experience with other primary producer countries, such as Australia, Canada, Philippines, New Zealand, and South Africa, as shown in Fig. 12. In this case, Chile performs better; for example, South Africans were taller than Chileans at the beginning of the century, but have been smaller since the 1960s. Chileans are now taller than men in the Philippines, as they were during the 1900s and 1930s–1940s, although the gap in the 1980s is in Chile's favour. Chile performs less well than Canada, but both countries show a fairly similar long-term height evolution.³³

The positive side of this Chilean divergence from developed countries in biological welfare is that the divergence in GDP per capita is even larger, as shown in Fig. 13. In 1900, per capita GDP in Chile was 23% and 5% higher than in Spain and Sweden, respectively. In contrast, in 1990, Chilean per capita GDP was nearly half that of Spain and nearly a third lower than that of Sweden. There was also a substantial divergence in GDP per capita when Chile was compared to the USA, the UK, and the Netherlands.

³³ We thank a referee for this journal for raising this point.

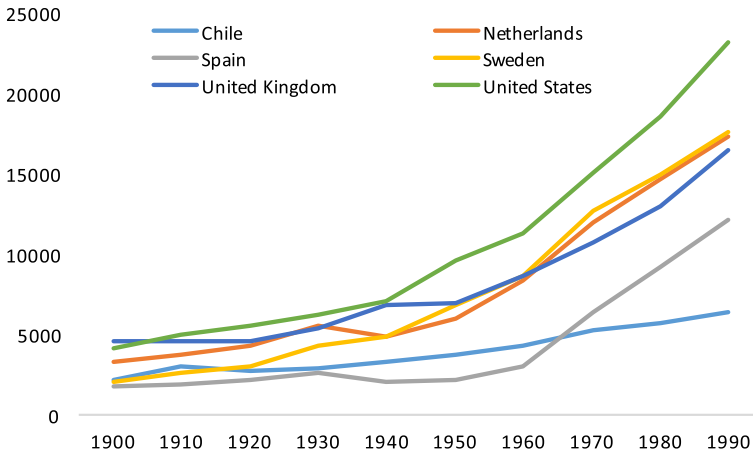


Fig. 13 GDP per capita (international 1990 Geary-Khamis dollars), Chile and other selected countries. Source: <http://hdl.handle.net/10622/8FCYOX>

7 Conclusions

In this article, we provide the first series of Chilean adult male height for the entirety of the twentieth century, an under-researched period in anthropometric studies, and Latin American history. Our sample represents only 5–7% of all conscriptions, and these shares vary overtime for the most relevant age ranges. The sample is not perfectly representative of the entire population, but it is a good proxy of it. Our preliminary results show that the height of adult males increased by about 5.5 cm during the twentieth century, an increase that mainly took place during the second half of this period. This is the largest improvement in biological welfare in Chilean history, at least from the 1730s, the first decade for which there is data available. Chilean males have never been as tall as they are today. However, the growth of human stature was larger in most developed countries for which there is comparable evidence. Chilean biological welfare diverged from that of the leading countries of the world, although divergence in GDP per capita was even greater.

It is worth stressing that this period of height increase coincided with many positive developments taking place in Chile, which fostered an improvement in biological welfare: an increase in the per capita consumption of milk during the 1930s–1960s and the 1990s–2000s; a dramatic increase in meat consumption during the last two decades; the implementation of several social policies to improve both feeding habits and the personal hygiene of the population; an increase in the share of the population enjoying health care, vaccination campaigns, antibiotics, sewerage services, and drinking water facilities; an increase in life expectancy and a substantial decrease in child mortality; and better education. Our results are, therefore, in line with those of Núñez and Pérez (2015), who found that height inequality in urban boys decreased in Chile from the 1940s to the 1990s due to an increase in public social expenditure (as a share of GDP) and the implementation of social

policies aiming to improve nutrition, health, and education. We can also add that the subsequent height increase in the 1990s can be largely attributed to a much better diet, in particular if compared to that of the 1960s–1970s.

Finally, we found a negative and significant correlation between dark skinned soldiers and height (although soldiers classified as whites were only 1 cm taller than the rest), while soldiers born in the centre of the country were slightly taller than those from the South and the North. Our results suggest that in Chile, if compared to other Latin American countries (such as Mexico or Colombia), there was both less ethnic inequality and less birth place inequality in height than elsewhere in the region. This factor is attributable to the biological welfare of Chile.

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Appendix 1

See Table 8.

Table 8 Raw average height of Chilean soldiers per decade of birth, for those aged between 20 and 55

Decade of birth	Obs	Raw average	Min	Max	SD
1900s	3635	166.2	138.0	190.0	5.9
1910s	3681	167.0	145.0	191.0	5.4
1920s	2463	167.3	137.0	185.0	4.9
1930s	2052	168.5	144.0	190.0	5.1
1940s	2976	168.0	148.0	189.0	5.4
1950s	8259	168.9	145.0	196.0	5.5
1960s	1150	170.5	151.0	195.0	5.6
1970s	1785	171.2	150.0	198.0	6.2
1980s	2594	171.7	148.0	202.0	6.0
1990s	1434	172.4	158.0	195.0	6.0
Total	30,029	168.7	137.0	202.0	5.9

Appendix 2

See Table 9.

Table 9 Occupations in the censuses of 1907, 1920 and 1930, and in our sample, per broad categories

Occupation	Our sample data, for the 1900s–1930s (%)	Census data 1907 (%)	Census data 1920 (%)	Census data 1930 (%)
Professionals	2.4	2.6	3.0	5.9
Skilled workers	40.5	40.9	27.4	22.7
Military	2.4	2.5	1.6	3.9
Students	9.3	0.0	19.0	0.0
Technicians	3.5	0.6	0.5	0.8
Unskilled workers	41.9	53.3	47.8	66.7
Unavailable	0.0	0.2	0.7	0
Total	100	100	100	100

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